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Soil Survey

of

The Oceanside Area, California

By

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and

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United States Department of Agriculture

Bureau of Chemistry and Soils

In cooperation with the
University of California Agricultural Experiment Station

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SOIL SURVEY OF THE OCEANSIDE AREA, CALIFORNIA

By R. EARL STORIE, University of California, in Charge, and E. J. CARPENTER, United States Department of Agriculture

AREA SURVEYED

The Oceanside area, Calif., covers 577 square miles, or 369,280 acres, situated in the northwestern part of San Diego County and comprising less than one-sixth of the total area of the county. Its location and boundaries are shown on the accompanying small outline map. (Fig. 1.) The area is approximately 15 miles wide, from east to west, and 36 miles long, from north to south.

The Oceanside area consists of a mountainous district, which covers the eastern half, and a coastal plain of broad flat-topped but dissected terracelike areas, that extend from the mountains westward to the ocean. In the mountainous part are a number of lowland areas, among which are Escondido, San Marcos, San Pasqual, and Poway Valleys.

FIGURE 1.—Sketch map showing location of the Oceanside area, Calif.

The coast line is formed by sea cliffs, ranging from 40 to 100 feet high, bordered by a narrow stretch of beach sand.

The seaward parts of the stream valleys are low and marshy, with lagoons near the sea that contain water during the rainy season but dry up during the summer, exposing broad flat areas heavily coated with salts. Most of the lagoons are entirely cut off from the sea by sand bars, so that drainage water must percolate through the sand, except during floods, when the bars may be washed out. The stream valleys lie at an elevation ranging from 200 to 300 feet below the general level of the flat-topped mesas of the coastal plain.

The average width of the coastal plain in the Oceanside area is about 8 miles, with an elevation on the east ranging from 500 to 600 feet above sea level, where the plain gives way to the higher elevation of the mountains.

The eastern half of the area, or the mountainous district, consists of rugged, rocky ridges having a northwest-southeast trend, with granite as the most common rock, and lowland areas within which rocks with low resistance to weathering outcrop. Extending from Fallbrook south to San Luis Rey River is a broad flat-topped granite ridge which is very smooth and free of bowlders and irregularities in surface relief as compared to the territory to the east.

Poway Mesa, in the southeastern part of the area, represents remnants of a very old and much eroded marine delta which is higher than the other terraces of the coastal plain, ranging from 600 to 1,100 feet above sea level.[1]

The Oceanside area is not forested, although a few scattered live oaks grow in the interior lowland areas. Most of the uncleared land of the coastal plain has a thick cover of chamiso, and native grasses spring up on the open spots after the winter rains. Wild oats, bur clover, and alfilaria are the most common native forage plants.

A number of large Indian rancherias and a fairly large Indian population were in this part of San Diego County before the founding of the missions. The San Diego Mission was founded in 1769 and the San Juan Capistrano Mission in 1776. The mission fathers and the Spanish authorities recognized the distance between the San Diego Mission and the San Juan Capistrano Mission to be too great for a day's journey on foot, so the San Luis Rey Mission was founded in 1789, with a station established at Pala soon after. Until 1846 the territory was under Mexican rule, and land grants were distributed by the square league. Even after the Americans came in 1846 the large ranchos remained closed to settlement, so that the population in this part of the area did not increase until the eighties when the Escondido, Poway, and San Marcos districts were settled. Most of the early settlers on the land grants were of Spanish extraction. American immigrants from the eastern part of the United States came in and took up land outside the Spanish land grants after California was taken over by the United States.

The 1930 census [2] gives the urban population of San Diego County as 174,032 and the rural as 35,627. The majority of the urban population is in the city of San Diego. The density of the rural population in San Diego County, according to the 1930 census, is 8.4 persons a square mile. The population has increased greatly within the confines of the area surveyed during the last five years, owing to extensive real-estate promotion, the establishment of irrigated districts, and the extension of avocado culture along the coast. The large majority of the population is native white. A few Indians, Japanese, and Chinese live in the area.

San Diego, the county seat of San Diego County, lies 15 miles south of the southwest corner of the Oceanside area. It has a population of 147,995, according to the 1930 census. Oceanside, the largest city within the Oceanside area, has a population of 3,508, and Escondido has 3,421. Escondido, Vista, and Fallbrook are the principal inland towns, and on the coast Oceanside, Carlsbad, Leucadia, Encinitas, Cardiff, Solana Beach, and Del Mar are rapidly developing as seaside resorts.

Transportation facilities are good. The Atchison, Topeka & Santa Fe Railway extends along the coast and has two branches connecting with inland points, one with Fallbrook and the other with Vista and Escondido. Two concrete State highways extend through the

[1] ELLIS, A. J., and LEE, C. H. GEOLOGY AND GROUND WATERS OF THE WESTERN PART OF SAN DIEGO COUNTY, CALIFORNIA. U. S. Geol. Survey Water-Supply Paper 446, 321 p., illus. 1919.

[2] Soil-survey reports are dated as of the year in which the field work was completed. Later census figures are given whenever possible.

area from north to south, so that farm products can be quickly moved to market in San Diego or Los Angeles, and good county roads traverse the developed parts. The settled parts are well supplied with schools, churches, telephones, and other modern conveniences. High schools are located at Oceanside, Escondido, and Fallbrook, and motor busses provide transportation for students from the surrounding territory.

CLIMATE

The climate of the Oceanside area is characterized by a long comparatively rainless growing season. About 75 per cent of the rainfall comes in December, January, February, and March. The total rainfall gradually increases with increase in elevation to the east. Records along the coast show an average annual rainfall between 9 and 13 inches. The average at Oceanside for a 10-year period is 12.85 inches.

Escondido, at an elevation of 657 feet, received an average of 17.14 inches over a 29-year period. The total rainfall in the driest and wettest years show a great difference, the records at Oceanside showing 5.76 inches in 1910 and 19.77 inches in 1915. Escondido received 7.96 inches during the driest year and 27.98 inches in the wettest year.

The district immediately along the coast is visited by heavy summer fogs that contribute much humidity to the atmosphere and aid in the growing of summer crops, such as beans. The fogs usually occur during the early morning but occasionally remain all day. This district has a marine climate which is temperate and has but slight variation in the seasonal and daily range of temperature. Temperatures probably show less range here than anywhere else in the United States.

Temperatures in the inland part of the area have a greater daily, as well as seasonal, variation. Temperatures of 100° F. or more are often experienced at Escondido and Poway during the summer, but the general humidity is a great deal lower in the warmer inland district, so that such temperatures are not highly uncomfortable.

Killing frosts rarely occur at Oceanside and in the territory immediately bordering the coast. This accounts to a large degree for the development that has taken place in avocado, winter vegetable, and flower culture in this part of the area.

The average date of the first killing frost at Escondido is November 18 and of the last is March 9. The average dates at Poway are November 24 and February 21. Both stations are located in inclosed valleys about 15 miles from the coast. A great difference is noted locally in frost conditions, depending on the local surface relief, exposure to coast breezes, and general air drainage. Some slopes having good air drainage are not subject to killing frost, but frost often occurs a short distance away in depressions and valleys. For this reason, citrus-fruit and avocado trees are usually grown on land having a sloping surface, and local valleys or depressions are avoided wherever possible. The Fallbrook, Vista, and Rancho Santa Fe districts are exposed to the sea breezes, though they are a few miles inland, so are comparatively frost free.

The prevailing winds are from the west and are moderate. The inland districts occasionally experience hot winds from the east, which account for high temperatures at such times.

The normal monthly, seasonal, and annual temperature and precipitation, as reported by the United States Weather Bureau station at Oceanside, are given in Table 1.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Oceanside, Calif.*

[Elevation, 60 feet]

Month	Temperature			Precipitation		
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1910)	Total amount for the wettest year (1915)
	° *F*	° *F*	° *F.*	*Inches*	*Inches*	*Inches*
December	55 1	88	31	1 71	0 37	3 12
January	54 4	84	21	3 82	1 62	6 51
February	53.8	82	34	2 39	.11	5 75
Winter	54.4	88	21	7 92	2 10	15 38
March	56 8	95	36	1 99	1 76	50
April	59 0	89	39	92	07	2 73
May	61 2	82	44	22	(1)	51
Spring	59 0	95	36	3 13	1 83	3 74
June	65 2	86	49	.10	06	(1)
July	68 8	86	52	04	28	.00
August	69 4	86	53	02	01	(1)
Summer	67 8	86	49	16	35	(1)
September	68 2	106	52	12	.05	(1)
October	64 4	102	43	.56	66	.00
November	60 6	95	33	96	77	.65
Fall	64 4	106	33	1 64	1 48	.65
Year	61 4	106	21	12 85	5 76	19.77

[1] Trace

AGRICULTURE

A crude type of agriculture was carried on by the mission fathers, with the aid of the Indians, soon after the founding of the San Luis Rey Mission in 1798, but the need of water for irrigating the crops in San Luis Rey Valley was soon realized and water was brought a long distance for this purpose. Grazing cattle and sheep was the chief industry. In 1800 the mission had 450 head of cattle, 1,600 sheep, 148 horses, and 14 mules,[3] and by 1828 the numbers had increased to 25,674 head of cattle, 28,913 sheep, 1,232 goats, 295 pigs, 2,226 horses, and 345 mules—a total of 58,685 domestic animals. This was the high point in the development of livestock at the mission and probably was the high point of livestock production for the area.

Sheep and cattle grazed over much of this area until recent years. In 1919 and 1920 several large flocks of sheep were still maintained, but since 1920 sheep have practically disappeared. A rather large number of beef cattle are still maintained in the area east of Del

[3] ENGELHARDT, Z. SAN LUIS REY MISSION. 265 p., illus. San Francisco. 1921.

Mar, and a small herd of Devon cattle is maintained in the Fallbrook section; but aside from these, grazing has practically passed out as an agricultural industry.

The lands controlled by the San Luis Rey Mission in 1822 extended 11 leagues from north to south and 15 leagues from east to west. Orchards and vineyards were established at San Luis Rey and Pala. By 1829 there were 3,000 Indians on the mission lands, but soon after this the lands were taken from the Indians by the Governor of California and given to private individuals under the Mexican flag. Up until 1846 the production of hide and tallow was the important industry of the area, these commodities being shipped in large quantities from the port of San Diego by the owners of the large land grants. Until the Americans came there were no plows. The hide and tallow trade practically ended with the transfer of California to the United States, and the beef industry developed rapidly after this. Beekeeping sprang up as an important industry in the back country about 1878. The Escondido and San Marcos districts were opened to general settlement in 1886 and 1887.[4] The Poway, Fallbrook, and San Pasqual districts were never included in the Spanish land grants so were early developed for general-farming purposes.

According to the Federal census of 1880, there were in that year 696 farms in San Diego County with a total of 559,390 acres, or an average of 804 acres a farm. In 1890 the number of farms was 2,474, the total acreage in farms 887,796, and the average size of farms 359 acres. In 1930 the number of farms had increased to 3,902 and the average size had decreased to 213.6 acres. At the present time the farms in the rough mountainous country in the eastern part of the Oceanside area are large and those in the intensely developed district along the coast range in size from 1 to 10 acres.

In 1929, $431,126 were expended in the county for fertilizer (including commercial fertilizer, manure, and lime), an average of $357.78 a farm for the 1,205 farms reporting. Most of the fertilizer is used for potatoes, flowering plants, truck, and citrus fruits and is bought ready mixed. For potatoes and general truck crops a 4–8–4[5] or 4–8–5 fertilizer is used.

Owners operate a large percentage of the farms of the county, tenants 10.8 per cent, and a very small percentage is operated by managers. Land used for grain, hay, and dry-farmed crops is usually rented on a share basis, the owner usually receiving one-fifth of the grain crop. Nearly all irrigated farms are rented for cash.

The farm laborers are largely Mexicans. They are paid about $3 a day and board themselves. Tractor operators and other special laborers are supplied locally.

The larger farms are well equipped with power machinery. On the small intensively cultivated tracts along the coast much of the work is done by agricultural contractors who own the necessary equipment for cultivation of the land. Most of the farm buildings are of light construction because of the mild climate, and large weatherproof barns are not needed. Farm dwellings in the irrigated

[4] VAN DYKE, T S. CITY AND COUNTY OF SAN DIEGO. 218 p., illus. San Diego, Calif. 1888.

[5] Percentages, respectively, of nitrogen, phosphoric acid, and potash.

districts are, as a rule, very fine buildings, and in the avocado and citrus districts people of means have constructed residences of distinction and taste.

Dairying is an important industry along the river valleys where alfalfa can be produced cheaply, and the poultry industry has expanded rapidly, particularly in the Escondido and Fallbrook sections.

In point of value of land, buildings, and livestock, the dairy industry is the leading livestock industry in this section. Most of the animals are high-grade Holstein-Friesians, Guernseys, and Jerseys, as practically all the herds are sired by purebred bulls and there are also many purebred cows. However, very few purebred herds are in the area, and breeding has not assumed importance. Dairying is carried on intensively, and many of the ranches do not purduce all the roughage that is fed to the animals. A large quantity of alfalfa hay is shipped into the area to be fed to dairy animals, and practically all the dairymen buy their grain concentrates. The milk produced is sold largely in San Diego as fresh milk, and the quality is high.

Based on the number of persons actively engaged in it, the poultry industry ranks first among the livestock industries. This industry is well established on a commercial and highly specialized basis, and it appears to offer some opportunity for further expansion. The average flock of poultry includes about 1,000 laying hens, although some flocks comprise more than 4,000. The chickens are largely White Leghorns, and a few rather large flocks are Rhode Island Reds. Most of the commercial poultrymen replace their flock with pullets each year, and a number of hatcheries located in the area supply day-old chicks. The eggs produced are handled by a cooperative poultry organization at Escondido and are sold largely in the Los Angeles market.

In growing specialized crops, such as citrus fruits, avocados, bulbs, and winter vegetables, climate is a very important factor. These crops can be grown only in frost-free or comparatively frost-free districts, and the frost danger, together with the water supply, is usually considered first. In fact in many places in the area such crops are grown on poor soils because of an available water supply and because the location is comparatively frost free.

Citrus fruits bring in one of the highest returns of any of the crops grown. The largest acreage occurs in Escondido Valley, where 2,500 acres are reported to be irrigated by the Escondido Mutal Water Co. More than 80 per cent of the acreage of citrus fruits in this district is grown on Fallbrook fine sandy loam with good results. The Vista irrigation district reports 899 acres of orange and lemon trees (1929). More than 60 per cent of these are growing on Vista sandy loam, the rest on a large number of soils that are not so desirable for the culture of these fruits. The acreage of citrus fruits in the Fallbrook district, of which lemons make up the greater proportion, is limited by the present water supply. The district is practically frost free, and the soils are Vista sandy loam and Fallbrook fine sandy loam. Both are deep soils, free of stone, and are considered highly desirable for citrus fruits. A large acreage of young citrus trees has been planted on the Rancho Santa Fe, on a wide variety of soils, many of which are shallow or have been

so badly eroded that the subsoil is exposed on the surface. Care must be used in the irrigation of these soils. Bean straw and other organic manures are used to build them up.

Avocado growing is an industry that has developed within the last five years in the Oceanside area. Before 1925 there were only a few small plantings, but now (1929) most of the land included in the irrigated districts on the coastal plain is rapidly being set out to this fruit. The Vista irrigation district reported 19 acres devoted to avocados in October, 1926; 395 acres in December, 1927; and 1,350 acres in May, 1929. Plantings of this fruit have increased in the same proportion along the coast from Oceanside to Solana Beach and on the Rancho Santa Fe. More than 1,000 acres are now in avocados along the immediate coast line, in addition to those in the Vista and Rancho Santa Fe districts.

The primary limiting factor in avocado growing is the occurrence of low winter temperatures, and, as the trees are also sensitive to high summer temperatures, they seem to thrive best in the more humid coastal districts. The avocado tree is extremely sensitive to poor drainage, and soils that are shallow, poorly drained, or contain much alkali are undesirable for avocado production. Along the coast more than 80 per cent of the avocados are grown on Elkhorn loamy sand which has a mellow surface soil and a pervious well-drained subsoil, providing favorable conditions for root and moisture penetration. The water-holding capacity can be built up by adding bean straw and manures or by growing cover crops.

The avocado does not do so well on soils having heavy clay subsoils, such as Olivenhain loamy fine sand. The subsoil of this soil consists of very stiff waxy clay that restricts the movement of water and results in a rather poor condition of drainage and aeration. Some very good young groves are growing on Vista sandy loam and Fallbrook fine sandy loam in the Vista and Fallbrook districts. In comparing groves at the present time, it must be remembered that practically all the trees are less than five years of age and, being small, will not respond so readily to adverse soil conditions as will older trees.

Grapes are extensively grown in the district contiguous to Escondido Valley. More than 75 per cent of the grapes are of the muscat varieties. They are shipped fresh to the coast and eastern markets. It is estimated that more than 4,000 acres are devoted to grapevines in this district. The coastal plain is not considered desirable for grapes, owing to the more humid atmosphere. Grapes are usually grown without irrigation, and in years of low rainfall yields are low. More than 50 per cent of the grapes are grown on Fallbrook fine sandy loam and the remainder on Escondido silt loam, Ramona sandy loam, and Merriam sandy loam.

The growing of truck crops is an important industry, especially along the coast where winter crops are not damaged by frost and mature at a time when prices are good. Winter potatoes, peas, squash, and cucumbers are successfully grown during the off season on Elkhorn loamy sand. In 1929, 300 acres were in squash, 680 acres in garden peas, 1,247 in potatoes, 2,023 in tomatoes, and 151 acres in cucumbers. The acreage of tomatoes is well scattered over the Vista and Escondido districts. Tomatoes are grown both with and with-

out irrigation. String beans and Lima beans are grown near the coast on a wide variety of soils. The nonirrigated acreage occurs in the valleys where the soils are deeper and contain more moisture. Spring and summer vegetables are extensively grown in San Luis Rey Valley and other valleys. Hanford fine sandy loam and Foster fine sandy loam are very desirable for such crops.

Bulb and flower growing have rapidly come to the front as a leading agricultural industry along the coast. This industry is centralized on Elkhorn loamy sand in the Carlsbad, Encinitas, and Solana Beach districts. Here the climatic conditions are favorable for growing market flowers when they are not available elsewhere. Bulbs mature early, owing to the sandy soil and the mild climate.

Alfalfa is produced in the San Luis Rey Valley and other small valleys where cheap irrigation water can be obtained from wells. The soils are deep and easy to irrigate. Most of the alfalfa is produced on soils of the Hanford, Foster, Greenfield, and San Marcos series.

Grain and grain hay are produced on those soils which are incapable of more intensive development, either owing to lack of water or poor climatic conditions. Barley occupies a larger acreage than wheat. Grain is grown to some extent on all the soils, but especially on the soils of the upper coastal-plain region. The small acreage in corn is almost entirely on the bottom lands along the streams.

Very little attempt is made to follow any system of crop rotation. A certain sequence of truck crops, such as peas, lettuce, or squash during the winter and beans in the summer, is followed by many growers, and these crops are often grown between young trees before they bear fruit. The practice of intercropping between older trees is to be discouraged as such crops rob the fruit trees of plant food and moisture.

More than 200 varieties of avocados are grown in California at the present time, although many of these are yet in the experimental stage. The Fuerte is the most popular variety in this area, and the Dickinson, Anaheim, and Puebla are also popular. Cultural operations in avocado orchards are similar to those practiced in citrus orchards. The young trees are usually protected by some type of wind shelter or screen. Along the coast high lath fences are common. As the avocado is a shallow-rooted tree, abrupt changes in depth of plowing or cultivating are likely to cause injury. Barnyard manure is the most common fertilizer used and is highly recommended for use on the soils of the Elkhorn series and other soils deficient in organic matter, and bean straw is also giving good results. Nitrogenous commercial fertilizers are applied to the trees, and cover crops, consisting of purple vetch and sweetclover (*Melilotus indica*), are grown with the aid of the winter rainfall and turned under in the spring to improve the physical condition of the soil as well as to supply needed organic matter.

Avocado trees are native to regions of high rainfall which comes during the growing season, hence, in this area, where the rainfall is low, they require an adequate supply of irrigation water. Experience has shown that from 1 to 2 acre-feet of water are required each year. Irrigation water is applied by means of furrows, basins, and overhead sprinkling systems. The last method is becoming very popular for other crops as well as avocados, as the water can

be applied uniformly on sandy soils and on fairly steep slopes, and it requires very little attention after the water is turned on.

For additional information on the culture of avocados the reader is referred to Avocado Culture in California.[6]

The methods used in handling citrus fruits in the Oceanside area are the same as those in use throughout the State. Orchard heating is used in the colder districts. From 1½ to 2½ acre-feet of water per annum are used on bearing citrus trees, the larger quantity being used in the warmer valleys in the eastern part of the area. Barnyard manure, bean straw, and nitrogenous fertilizers are used to maintain the fertility of citrus lands. Cover crops are grown during the winter and plowed under after the rains cease in the spring.

Potatoes are usually planted in the fall or early winter and harvested in March and April. From 800 to 1,000 pounds of commercial fertilizer, consisting of 4–8–4, 8–8–4, and 7–12–6 mixtures, are applied at the time of planting on the sandy soils of the coastal plain. The potatoes are shipped as new potatoes in lug boxes, and they command a good price. Potatoes are grown on both irrigated and nonirrigated land.

String beans of the Kentucky Wonder variety are grown near the coast on many of the small ranches and are harvested in late spring. Lima beans have long been a favorite crop for the coast district. They are planted between April 15 and May 15 and are harvested in late summer and early fall, the yields ranging from 6 to 12 sacks an acre, although yields on irrigated land, consisting of good soil, are heavier.

The acreage of tomatoes varies greatly from year to year. The early crop is planted in May and harvested in July, and later plantings are harvested from October to January.

The acreages of barley, wheat, and oats are gradually decreasing each year as more intensive crops are grown and as more land is put under irrigation. These crops are planted in December and January so that they benefit from the season's rain. Some land is summer fallowed, but the acreage is not large. The principal varieties of wheat are Defiance and Escondido; of barley, Golden Mariout; and of oats, Red Rustproof (Red Texas). Yields of grain vary greatly, owing to the variable amount of rainfall.

Alfalfa is cut from four to six times a season and yields from 5 to 8 tons an acre on the deep soils of the river bottoms. Much of the alfalfa is used for pasture for dairy cows. Alfalfa land must be irrigated once or twice a month during the growing season. The irrigation water is supplied from wells, and the water is distributed over the alfalfa fields by means of border checks.

SOILS AND CROPS

The area covered by the soil survey of the Oceanside area is included in that of the earlier Reconnaissance Soil Survey of the San Diego Region.[7] In this earlier survey soil mapping was conducted on a much more extensive and less detailed scale than in the

[6] RYERSON, K. A. AVOCADO CULTURE IN CALIFORNIA. PART I. HISTORY, CULTURE, VARIETIES AND MARKETING. Calif. Agr. Expt. Sta. Bul. 365: [575]–629, illus. 1923.

[7] HOLMES, L. C., and PENDLETON, R. L. RECONNAISSANCE SOIL SURVEY OF THE SAN DIEGO REGION, CALIFORNIA. U. S. Dept. Agr., Bur. Soils, Field Oper. 1915, Rpt. 64: 2509–2581, illus. 1919.

present survey, in which a much smaller area is classified and mapped in much greater detail. Owing to the more intensive study in the later survey, resulting in the recognition of soil series and soil types not recognized or differentiated in the broader and less detailed classification of the earlier survey, a number of apparent conflicts in classification in the soils of the two surveys occurs. The more important of these are noted under the discussions of the various soil series and types which follow. Many of the apparent inconsistencies in classification represent a normal development in the science of soil classification during the period of some 15 years intervening between the time of the two surveys.

Because of the wide range in agriculture practiced in the area and the large number of divergent soil types, it would be difficult to designate the particular types that dominate the agriculture. A few soil types cover fairly large areas, but in general each type covers a small area.

In the following pages the soils of the Oceanside area are described in detail and their agricultural possibilities are discussed, the accompanying soil map shows their distribution and location, and Table 2 gives the acreage and proportionate extent of the different soils.

TABLE 2.—*Acreage and proportionate extent of the soils mapped in the Oceanside area, Calif.*

Type of soil	Acres	Per cent	Type of soil	Acres	Per cent
Vista sandy loam	35,840	9 7	Greenfield sandy loam	6,592	2.6
Fallbrook fine sandy loam	45,824	12.4	Calcareous-subsoil phase	2,816	
Las Posas stony fine sandy loam	6,208	1.7	Botella loamy sand	2,560	1 2
Konokti stony loam	2,432	.7	Brown phase	1,664	
Escondido silt loam	8,256	2.2	Botella sandy clay loam	1,856	.6
Altamont clay loam	2,752	2.2	Brown phase	384	
Gravelly phase	5,504		San Marcos fine sandy loam	1,920	5
Altamont clay	8,000	2 2	San Marcos loamy fine sand	832	.2
Diablo clay	5,312	1.4	Salinas clay loam	1,920	5
Ayar clay loam	2,240	.6	Ramona sandy loam	4,544	1.3
Linne clay	3,072	.8	Stony phase	256	
Elkhorn loamy sand	8,000	2.2	Merriam sandy loam	15,168	4.1
Carlsbad loamy fine sand	6,976	2.7	Merriam fine sandy loam	2,944	1.1
Gravelly phase	3,008		Clay phase	1,088	
Tierra loam	3,136	.9	Huerhuero fine sandy loam	4,928	1 3
Las Flores loamy fine sand	11,520	4.4	Redding gravelly sandy loam	13,184	3.6
Eroded phase	4,928		Monserate sandy loam	3,456	.9
Olivenhain loamy fine sand	8,256	2 2	Rough stony land	90,048	24 4
Hanford fine sandy loam	7,744	2 1	Rough broken land	16,704	4.5
Tujunga fine sand	3,968	1.1	Tidal marsh	1,536	.4
Foster fine sandy loam	3,008	.8	River wash	4,096	1.1
Alviso loam	2,368	.7	Coastal beach and dune sand	576	.2
Laguna loamy sand	1,856	.5			
			Total	369,280	

VISTA SANDY LOAM

Vista sandy loam has a brown friable sandy loam surface soil and a slightly heavier subsoil that grades into decomposed granitic bedrock at a depth ranging from 30 to 60 inches. This is locally known as "brown granite soil." The soil is easy to till and seems very productive when sufficient moisture for crop growth is present.

One large body of this soil, more than 40 square miles in extent, lies south and east of Fallbrook. Other important areas are scattered over the eastern part of the area surveyed, east of Vista and

bordering Escondido Valley. Some stony areas occur which are too stony for tilled crops and are used largely for pasture, but small patches in them can be farmed. Such areas are shown on the map by stone symbols.

Where water is available for irrigation, Vista sandy loam is a very desirable agricultural soil. In the Fallbrook district scattered orange, lemon, grapefruit, and avocado groves are planted where irrigation water is available. Under irrigation in the Vista district, this soil is used extensively for a variety of crops. Without irrigation grain and grain hay are the principal crops, and some olives and grapes are grown. In the Oceanside area Vista sandy loam occurs in frost-free or comparatively frost-free situations.

The water-holding capacity, as well as the organic-matter content of this soil, can be built up by turning under organic crop residues and green-manure crops. There is still a large acreage that can be used for intensively grown crops and for orchards when water is available for irrigation.

FALLBROOK FINE SANDY LOAM

The surface soil of Fallbrook fine sandy loam is brownish-red or dull-red fine sandy loam or sandy loam, which is very friable when moist. The soil has a tendency to bake and harden on drying, although the surface soil has good water-holding capacity. The subsoil is fine sandy loam which contains much colloidal material and is plastic, but it absorbs water fairly readily. The soil is easy to till when moist, and good results are obtained where sufficient moisture is available for plant growth. Fallbrook fine sandy loam is locally known as "red granite soil," on account of its color and the character of the parent rock underlying it.

This soil is one of the most extensive in the area surveyed, occurring in large bodies surrounding Escondido Valley, the Green Valley district, north and east of Vista, and in scattered areas east of Bonsall and Fallbrook. Stony areas, shown by stone symbols, occur in association with the areas of fine sandy loam which are free of large stones. The stony areas are somewhat rougher in surface relief, and their stone content reduces their agricultural value. They are largely used for pasture, although small areas can be tilled.

Fallbrook fine sandy loam is used for a wide variety of crops, with irrigation. Among these are citrus fruits, avocados, and general truck crops. Grapes (principally of the muscat varieties) are grown without irrigation in the Escondido and Poway districts, with grain, grain hay, and corn as the principal nonirrigated crops. Approximately 2,500 acres of this soil are devoted to citrus trees in the Escondido district. This land is under irrigation. Grapes are grown on more than 4,000 acres of nonirrigated land of this kind.

LAS POSAS STONY FINE SANDY LOAM

Las Posas stony fine sandy loam consists of dark brownish-red or red friable fine sandy loam. The surface soil is somewhat variable in texture, small areas occurring that contain less stone and are as heavy as clay loam. The soil proper averages less than 3 feet in

depth. Stones and rock outcrops occur in such abundance that most of the soil is used as pasture land, owing to the difficulty of tillage. The soil is typically nonmicaceous, and most of the stones, which range from a few inches to several feet in diameter, are angular. Just above the bedrock, the subsoil is slightly heavier in texture than the surface soil.

Several areas of this soil are north and east of Olivenhain, and smaller areas are east of Vista and bordering Black Mountain on the south.

Las Posas stony fine sandy loam is not an important agricultural soil, owing to the stony shallow character of the soil and the somewhat broken surface relief on which it occurs. Probably less than 10 per cent of the land is under cultivation at the present time (1929), although the acreage could be increased somewhat if water were available for irrigation. A few vineyards have been established in the areas of deepest soil, and some diversified agricultural development occurs in the Vista irrigation district.

KONOKTI STONY LOAM

Typically Konokti stony loam consists of a brown or slightly reddish-brown friable stony loam surface soil, underlain by a slightly heavier subsoil that grades into the parent bedrock. The soil is shallow and stony, bedrock in most places occurring within 3 feet of the surface. Small bodies occur within areas of this soil which do not contain much stone and are used for grain, hay, and general field crops, but as a whole Konokti stony loam is too rough and stony for tilled crops and is used for pasture. A fairly good stand of native grasses grows on this soil.

Konokti stony loam is associated with Las Posas stony fine sandy loam and occurs in scattered areas northeast of Olivenhain and in the vicinity of Black Mountain. Agriculturally it is of little importance.

ESCONDIDO SILT LOAM

Escondido silt loam consists of pale reddish-brown or yellowish-brown extremely friable and floury silt loam that extends to the underlying broken parent schist bedrock, typically without change in texture, structure, or color. The soil is easy to till, absorbs water readily, and has a good water-holding capacity. Underlying most areas, at a depth ranging from 24 to 40 inches from the surface, is shattered bedrock. The soil appears somewhat red when wet, and in the earlier reconnaissance survey it was included with the red soils of the Sierra and Aiken series.

Areas of Escondido silt loam occur north and east of San Marcos, south of San Marcos in the vicinity of Mount Whitney, and scattered bodies are directly south of Hodges Reservoir. Some areas have loose angular schist rock fragments over the surface and throughout the soil mass and are shown on the map by stone symbols.

Where water is available for irrigation Escondido silt loam is used for a wide variety of crops. Most of the soil occurs in comparatively frost-free situations on rolling hills. Citrus trees are grown in the districts northwest of Escondido and northeast of Buena on land that is under irrigation. Grapes, of the muscat varieties, are

grown on nonirrigated land. Probably 25 per cent of the soil is now in grapes or has been in grapes at some time in the past. Stony areas of this soil are not tilled to a great extent but are used mainly for pasture, though a small acreage is used for grapes. A fairly large irrigated mulberry planting is on this soil northeast of San Marcos. It is used in connection with a local silk-producing industry.

ALTAMONT CLAY LOAM

The surface soil of Altamont clay loam consists typically of brown or light-brown friable clay loam from 4 to 12 inches deep. As mapped, however, the texture ranges from fine sandy loam to light clay loam, the soil being generally slightly heavier in texture on the slopes and sandier on the tops of the ridges. This variation in texture is due, to a great extent, to erosion which is very active on the coastal-plain terraces where Altamont clay loam occurs. The surface soil rests on a brown, irregularly calcareous, compact clay layer that is extremely tight and waxy. The substratum or parent bedrock is moderately consolidated, intermittently calcareous fairly hard shale rock in the areas southeast of Del Mar. Erosion has exposed the subsoil in spots, and where this occurs the soil is hard to handle owing to the variable quantity of water contained, poor drainage, and stickiness of the soil material. The growth of deep-rooted crops is limited on this soil by the heavy compact character of the subsoil which prevents the penetration of roots and water to a great degree.

Areas of Altamont clay loam occur on the modified slopes of the coastal-plain terraces east and southeast of Del Mar and southeast of Olivenhain, and one area is southwest of Vista.

Grain and grain hay are grown without irrigation on Altamont clay loam, and yields ranging from 5 to 15 sacks [8] an acre of barley and wheat are obtained. In a good year hay will produce 1 ton or slightly more.

Altamont clay loam, gravelly phase.—The gravelly phase of Altamont clay loam has a profile similar to that of typical Altamont clay loam, with the exception of a covering of cobbles and gravel over the surface and throughout the surface soil. One area located 3 miles southwest of Black Mountain occurs on a flat-topped mesa, but the other areas west of this and southeast of Olivenhain occupy the rough broken slopes of mesas and have little value except as pasture land. There are small scattered areas devoted to general field crops, such as are grown without irrigation on the coastal plain. Probably more than 80 per cent of this gravelly soil is covered with brush, is eroded, and has little value except as poor pasture.

ALTAMONT CLAY

The surface soil of Altamont clay consists of rather dark dull-brown or rich-brown clay that is sticky and hard to till when wet and bakes very hard when dry. The subsoil in most places is calcareous and rests on calcareous bedrock at a depth ranging from 20 to 50 inches. The quantity of lime in the subsoil and depth to

[8] The capacity of grain sacks in the different markets of California ranges from 100 to 125 pounds, but the average is about 2 bushels.

bedrock are variable. Bedrock ranges in character from soft limestone to fairly hard material containing lime in the upper part.

Altamont clay has a high water-holding capacity and is considered desirable for grain, beans, and general farm crops, without irrigation. Most of the land has been cleared and has been farmed to some extent. The heavy texture, which hinders cultivation, has a tendency to limit the agricultural use of this soil to a great extent. Areas of Altamont clay in the Rancho Santa Fe and Vista districts have been planted to citrus fruits and avocados, with irrigation.

Areas of Altamont clay are scattered over the higher parts of the coastal-plain region at Vista, near Buena, 4 miles southwest of San Marcos, 4 miles southeast of Carlsbad, and in the Rancho Santa Fe district. One area west of Black Mountain contains much rock outcrop and loose stone and is redder than typical, and it is underlain by calcareous bedrock. This body of soil is used for pasture as the stone content is too great for plowing and the surface is broken. With the exception of the last-named area, Altamont clay occurs on rolling or hilly slopes that can be farmed. On the steeper slopes some difficulty is experienced in applying irrigation water, as the soil absorbs water slowly owing to its heavy character. A few eroded spots occur, but as a rule the land is free from excessive erosion.

DIABLO CLAY

The surface soil of Diablo clay consists of dark-gray or black sticky clay that has a pronounced adobe structure in spots, in which the soil on drying checks and breaks into blocks separated by cracks. The soil hardens on drying; but under favorable conditions of moisture and tillage, the blocks and clods break down into smaller aggregates, causing the soil to be more easily handled than would otherwise be the case. When wet, the cracks close and the soil is black. The subsoil is lighter in color and, owing to the lime content, breaks up into small clods or granules when exposed to the air. At a depth ranging from 24 to 48 inches soft bedrock that is high in lime normally occurs. The surface soil contains a large quantity of organic matter.

Diablo clay occupies the tops and slopes of high terraces on the coastal plain. A number of areas of this soil occur northeast and east of Oceanside, west of Buena, east of Ponto, north of Rancho Santa Fe, and in the Vista district. One area south and another 2 miles northeast of Black Mountain have a surface covering of cobblestones from 2 to 5 inches in diameter. These two areas occur on the lower slopes of a high mesa and are used for pasture. Three small areas northwest of Vista have a nodular accumulation of lime in the subsoil and would have been mapped as Montezuma clay had they been more extensive.

Nearly all the areas of Diablo clay are, as regards surface relief, suitable for cultivation, with the exception of the stony areas in the vicinity of Black Mountain and small areas on terrace slopes, yet probably less than 50 per cent of the land has been cultivated. Dry-farmed grain and grain hay are the principal crops. A small acreage has been cropped to peas and beans with fair results, and a small acreage has been set out to avocados within the last three years, since the development of irrigation in the Vista and Rancho Santa Fe districts.

AYAR CLAY LOAM

The surface soil of Ayar clay loam consists of brown or rather dull grayish-brown clay loam that is loose and friable and has the appearance of being lighter in texture, owing to the high lime content. The subsoil is light-gray friable clay loam containing a large quantity of lime, with pieces of calcareous bedrock throughout the lower part. The highly calcareous consolidated parent bedrock occurs at a depth ranging from 18 to 48 inches below the surface.

This soil is inextensive in the Oceanside area. Several small bodies occur in the vicinity of Black Mountain and south and east of Rancho Santa Fe. The soil has a high water-holding capacity and, with its ease of tillage, is highly desirable for grain and grain hay. It occurs in gently rolling areas that can be easily farmed. A number of small areas in the vicinity of Buena have been recently brought under irrigation and planted to avocado trees.

LINNE CLAY

The surface soil of Linne clay consists of dark-gray or dark brownish-gray friable clay containing a large quantity of lime. The subsoil is calcareous, of dark-gray or light brownish-gray color, and of about the same texture as the surface soil. At a depth ranging from 18 to 40 inches, it rests on softly consolidated parent bedrock with a high content of lime. Fragments of this white bedrock occur throughout the soil mass, extending to the surface in places.

The soil has a high water-holding capacity and contains a large quantity of organic matter. It is sticky when wet but is friable when dry, owing to the high lime content.

The soil occurs on rounded grass-covered hills, the largest area being directly east of Black Mountain. Other areas in this locality are south and west of Black Mountain. Areas occur south of Buena, and a number of small bodies are scattered over the coastal plain.

Linne clay is used for dry-farmed grain and grain hay, and practically none of it is under irrigation.

ELKHORN LOAMY SAND

Elkhorn loamy sand is the important avocado, flower, and vegetable soil of the sandy coastal-plain district which extends from Oceanside south through Carlsbad, Encinitas, and Solana Beach. This soil, which was recognized as representing a distinct series of soils subsequent to the reconnaissance survey, was, in that survey, included with Kimball sandy loams.

Elkhorn loamy sand has a brown or light reddish-brown loamy sand surface soil, the texture of which is such that it can be tilled at any moisture content. When moist it is very friable, but it has a tendency to bake very hard on drying. The subsoil, of similar or slightly more yellowish-brown color, consists of moderately compact or semicemented sandy material, occurring at a depth ranging from 15 to 36 inches below the surface. When moist the subsoil does not show the same degree of compaction as it does when dry. The lower part of the subsoil is hard and compact although it is very sandy.

One area of Elkhorn loamy sand along the coast at Leucadia has a surface soil without compaction extending to a depth of 4 or 5 feet. Smaller areas of the soil, which have been subject to recent sand movement, are also deep.

A more or less continuous strip of Elkhorn loamy sand extends along the sea front from Oceanside south to Del Mar. This strip is from one-half to 1½ miles wide and slopes gently from the sea cliffs to an elevation of approximately 200 feet above sea level.

Most of the recent development of the avocado, truck-crop, and flower growing industries, made possible by the construction of irrigation works, has taken place on Elkhorn loamy sand. The Oceanside Mutual Water Co. serves the Oceanside and Carlsbad districts by means of pumped water from San Luis Rey Valley and the Leucadia, Encinitas, Cardiff, and Solana Beach districts obtain water for irrigation from Hodges Reservoir. One area of this soil between Agua Hedionda Creek and Batiquitos Lagoon does not have irrigation water available at the present time and is being used for growing potatoes and beans.

Other than areas reserved for residential purposes along the coast, all of Elkhorn loamy sand is used for crops, principally avocados, bulbs, flowers, and winter vegetables. Avocados are grown because of the desirable climatic conditions, as the nearness of the ocean has a tempering effect both on extreme heat and winter frosts. The sandy character of the soil is desirable for the culture of bulbs and winter vegetables. Probably 50 per cent of the irrigated area of Elkhorn loamy sand is set out to avocado trees, and the remainder is divided among bulbs, flowers, potatoes, beans, peas, squash, and uncultivated residential lots.

Although friable, easy to till, and warm, Elkhorn loamy sand is somewhat lacking in humus and general fertility. Applications of manure give good results, bean straw is very extensively used in avocado groves in addition to commercial fertilizers, and in growing truck crops and flowers, complete fertilizers containing nitrogen, phosphoric acid, and potash are used.

CARLSBAD LOAMY FINE SAND

Carlsbad loamy fine sand is associated with Elkhorn loamy sand on the sea front. This soil, which was in this survey recognized as representing a distinct soil series, was, in the reconnaissance survey of the San Diego region, included with undifferentiated materials in the Las Flores, Kimball, and San Joaquin sandy loams.

Typically the surface soil of Carlsbad loamy fine sand consists of pale reddish-brown friable loamy fine sand that contains many iron pellets about the size of small peas. These do not interfere with cultivation, although they are very conspicuous on the surface in places. The subsoil is about the same color as the surface soil, is moderately compact, but normally is not much heavier in texture than the surface soil. A cemented substratum of red sandstone underlies the subsoil at a depth ranging from 20 to 40 inches below the surface.

Areas of this soil occur near Oceanside, Carlsbad, Ponto, Leucadia, Encinitas, Cardiff, Solana Beach, and Del Mar, on the crests of

A, Area of Carlsbad loamy fine sand prepared for planting to avocados Note small circular basins in which trees are to be placed B, General view overlooking area of eroded phase of Las Flores loamy fine sand

Profile of Olivenhain loamy fine sand, showing surface soil, or A horizon, of friable loamy fine sand underlain abruptly by B horizon of drab heavy compact clay of solonetz structure, resting on C horizon of parent semicemented or consolidated marine sediments

ridges paralleling the coast line at an elevation ranging from 200 to 300 feet above sea level. The slopes and edges of the ridges are eroded and the depth of soil is variable, so that agriculture is limited by the degree of erosion.

More than 75 per cent of Carlsbad loamy fine sand is covered by brush and is not used for agriculture. Areas under irrigation that border Elkhorn loamy sand are used for avocados, flowers, and truck crops. (Pl. 1, A.) Nonirrigated early potatoes are grown on a few patches.

The general fertility and organic-matter content of this soil are low, and crops planted on it are heavily fertilized. For trees or deep-rooted crops, the soil is somewhat shallow, and this condition is further impaired by active erosion. The topsoil may be very thin in places.

Carlsbad loamy fine sand, gravelly phase.—The gravelly phase of Carlsbad loamy fine sand is associated with typical Carlsbad loamy fine sand, from which it is differentiated on the basis of the large content of gravel scattered over the surface and throughout the soil mass. Most areas of the gravelly soil are badly eroded and covered by a growth of chamiso and a little grass. In many places much gravel occurs on top of the substratum at a depth ranging from 20 to 40 inches.

One area just northeast of Oceanside contains less gravel than typical and has not been eroded very badly. This area is being used for a variety of crops with irrigation. Areas occurring east of Ponto, east of Encinitas, east of Solana Beach, and east of Del Mar have a high gravel content and in general are of low agricultural value. They are covered with brush and have not been cleared or farmed in any way. Eroded spots occur that are variable in gravel content, depth, and other characteristics.

TIERRA LOAM

The surface soil of Tierra loam consists of a 4 to 12 inch layer of dark brownish-gray or dull brownish-gray loam or light clay loam, which contains much fine sandy material. The soil material is moderately friable when moist but becomes hard and baked when dry. The subsoil ranges from dull-brown compact clay loam to clay. It is wet and puddled after heavy rains and hard and dry during the dry season. At a depth ranging from 20 to 36 inches this layer rests on partly consolidated sandstone or old marine sediments of finer texture, which may contain a quantity of alkali or saline salts.

This soil is somewhat hard to handle, as it puddles readily and bakes hard on drying; but when it is handled properly, good crops of beans, hay, and grain may be obtained without irrigation.

About 3,000 acres of Tierra loam occur in the Oceanside area. The two main areas are 3 miles northeast of Oceanside and Carlsbad, respectively, and a few small areas are in the vicinity of Rancho Santa Fe. They occupy old eroded marine terraces with flat tops and fairly steep slopes.

More than 75 per cent of the land is used for pasture, and the rest is used for grain, grain hay, peas, and beans without irrigation.

LAS FLORES LOAMY FINE SAND

The surface soil of Las Flores loamy fine sand consists of light-gray or light brownish-gray friable loamy fine sand which extends to a depth ranging from 4 to 12 inches, where it is abruptly underlain by heavy compact waxy clay. The clay layer rests on gray sandstonelike material at a depth ranging from 12 to 30 inches. In a few spots, which are too small to map, the clay layer is absent, and the gray soil grades directly into the underlying gray consolidated sediments. Las Flores loamy fine sand has a low content of organic matter and is, in general, of low fertility. The water-holding capacity of the surface soil is low, and the intractable character of the subsoil limits the penetration of roots and moisture. Considerable quantities of saline salts are present in the subsoil and substratum in most places.

Las Flores loamy fine sand occurs on eroded coastal-plain terraces, extending from a point east of Oceanside southward to a point east of Del Mar. The largest area, covering between 2,000 and 3,000 acres, is between Oceanside and Vista. Eighteen square miles of Las Flores loamy fine sand are in the Oceanside area.

Less than 10 per cent of Las Flores loamy fine sand is under cultivation, and the rest is covered by a growth of low brush, some of which has been cleared off and the land used for pasture. The stand of native grasses is poor in most places. Grain, grain hay, and general field crops are grown on the cultivated areas, and a few smooth areas near the coast are being used for peas and beans. Truck crops are grown with irrigation on a small acreage west of Vista. These crops are fertilized heavily, and care is used in irrigation. Only a few young avocado and citrus trees are planted on this soil.

Las Flores loamy fine sand, eroded phase.—The eroded phase of Las Flores loamy fine sand consists largely of eroded slopes with a few small areas of uneroded original soil material remaining. Areas of the eroded phase have a variable profile. The surface soil ranges from brown to gray in color, the subsoil may or may not have a clay layer, and the substratum is brown or gray sandstone which, when exposed to view by erosion, is the most noticeable characteristic of land of this phase. (Pl. 1, B.)

Small areas of soil material, most of which are gray, have been washed into depressions in the eroded territory, but they are too small to separate and show on the map. These areas, each only a few acres in extent, are used for general field crops without irrigation and for general truck crops where irrigation water is available.

Probably 5 per cent of this eroded land is under cultivation, and the rest consists of low brush-covered eroded slopes. The areas of soil of the eroded phase occur from a point north of Olivenhain south to Soledad Canyon. One small area is 3 miles south of Buena.

OLIVENHAIN LOAMY FINE SAND

The surface soil of Olivenhain loamy fine sand is brown or light reddish-brown friable loamy fine sand or sandy loam, ranging from 6 to 16 inches in depth. The subsoil differs from the surface soil in every respect, being dull-brown very compact waxy clay (pl. 2)

which may extend to a depth of 30 or more inches, where it rests on moderately consolidated sediments having the characteristics of soft sandstone or clay shale. The subsoil is comparatively impervious, and root development and moisture absorption are confined largely to the more pervious surface soil material. The organic matter content is low in most places. The lower part of the subsoil and the moderately consolidated material underlying it usually contain alkali salts in fairly large quantities.

Olivenhain loamy fine sand is mapped in several irregular-shaped areas widely scattered over the coastal plain. Areas are east of Oceanside, east of Carlsbad, northeast of Ponto, 1 mile east of Leucadia, 2 miles north of Olivenhain, on the Rancho Santa Fe, east of San Dieguito Valley, and southwest of Vista. A total of 12.9 square miles of this soil is mapped in the Oceanside area.

Probably 50 per cent of the land lies within the confines of irrigated districts where avocado and citrus trees have been set out recently. It is doubtful whether good results will be obtained from such plantings, as the stiff waxy clay subsoil restricts the downward movement of water and results in a poor condition of drainage and soil aeration. Truck crops and flowers, to some extent, are grown on the irrigated areas. They are fertilized heavily, and care is used in irrigation.

Most of the soil occurs on flat or gently rolling areas. Care must be used in irrigating, as the subsoil takes water slowly and the variable depth of the surface soil causes one spot to become saturated, whereas another is not moistened to sufficient depth.

Grain, grain hay, and, to a small extent, peas and beans are grown on the nonirrigated land, but approximately 50 per cent of such land is used for pasture.

HANFORD FINE SANDY LOAM

Hanford fine sandy loam typically consists of light-brown, brown, or light grayish-brown medium or rather coarse-textured micaceous fine sandy loam which may vary little in texture to a depth of 6 feet or more, though the subsoil may be made up of strata of various textures. The surface soil and subsoil are friable and porous, so that plant roots and moisture readily penetrate to a great depth. The surface soil contains only a moderate amount of organic matter and is only fairly retentive of moisture. Crops often suffer from drought where irrigation is delayed or is not practiced.

Hanford fine sandy loam is scattered in small valleys, on alluvial fans, and on flood plains of streams which occur over the eastern part of the area in the district of granitic rocks. Individually each of the areas is small, but collectively they amount to a rather large acreage. On the steeper alluvial fans the soil is coarser in texture and not so dark as it is on stream bottoms where there is more moisture and natural vegetation.

Hanford fine sandy loam as mapped in the canyon bottom south of Poway consists of gravelly sandy loam containing much cobbly material which represents outwash from the Poway Mesa. The subsoil is gravelly at a depth of 2 or 3 feet, and consequently this body of soil is of much lower value than typical Hanford fine sandy loam. Included spots are of sandy loam or fine sandy loam texture.

The uniform surface relief of areas of this soil as well as their location in valleys where underground water can be obtained for irrigation makes the soil desirable for a large number of irrigated crops, especially for alfalfa and general truck crops. A few walnut and deciduous fruit orchards are growing on it, but citrus fruits and avocados are not usually considered desirable, owing to the frost hazards in the lower valley lands. Good wells which furnish sufficient water to irrigate a large acreage have been obtained in the upper part of San Luis Rey Valley. Some difficulty is experienced in obtaining good flows in some of the smaller valleys where the flow of water through the gravel is insufficient.

Much of the soil is subject to overflow in time of unusual freshets, when coarse material is deposited over the surface or erosion channels are cut through the soil material.

The agricultural value of this soil is largely governed by the water supply. As a general rule, the land produces poorly under dry-farming conditions but is highly prized where water for irrigation can be obtained.

TUJUNGA FINE SAND

The surface soil of Tujunga fine sand consists of light-gray or light brownish-gray loose micaceous fine sand, with included areas of coarser texture. The material below the surface soil is of similar color but may be variable in texture. This soil represents very recently deposited material or material that is being deposited at the present time by unusual floods. It consists of particles of granitic rock that have not been deposited long enough to accumulate any organic matter.

An area of this soil borders the present channel of San Luis Rey River, one occurs in San Dieguito Valley south of Rancho Santa Fe, and one along the channel of San Dieguito River in San Pasqual Valley.

As Tujunga fine sand is subject to wash and overflow, it has not been used for cultivated crops to any extent. Brush and grasses have grown where moisture is received from percolating waters, and these grasses provide some pasture. A small acreage of alfalfa is grown, but a large quantity of water is required to maintain its growth on this coarse-textured soil.

FOSTER FINE SANDY LOAM

The surface soil of Foster fine sandy loam is dull brownish-gray or dark grayish-brown highly micaceous friable fine sandy loam containing much lime. The soil material below the surface layer, to a depth of 6 feet, is of the same character as the surface soil, except that it is stratified and the texture ranges from sandy loam to loam. When moist the soil appears browner. It absorbs water readily, holds it well, is easily tilled, and has a fairly high content of organic matter.

The largest body of Foster fine sandy loam occurs in the San Luis Rey Valley northeast of Oceanside, other areas are in San Dieguito and San Pasqual Valleys, and one body is in Moosa Canyon near Bonsall.

Some areas of this soil are subject to poor drainage, as they occur on flat valley floors. Most of the poorly drained areas have a salt-

grass cover and an accumulation of alkali salts. Tests made at the lower ends of San Pasqual and San Luis Rey Valleys showed an alkali content, ranging from 0.4 to 1.5 per cent, to a depth of 4 feet. The alkali is largely sodium chloride, with a small amount of black alkali. These spots are not being farmed. The better-drained areas show a small quantity of alkali, but they can be successfully farmed when the water table is kept at a safe depth below the surface.

The better-drained areas of Foster fine sandy loam are considered highly desirable for alfalfa and truck crops. Water is obtained from wells in the San Luis Rey, San Dieguito, and San Pasqual Valleys, and, as the lift is low, water for irrigation is comparatively cheap.

Asparagus and other specialized truck crops grown on this soil in San Luis Rey Valley are shipped each year from Oceanside. Except for the poorly drained alkali areas, all the Foster fine sandy loam is under cultivation to truck crops.

ALVISO LOAM

Alviso loam includes soils which are mottled drab and dark brownish gray and are variable in texture, although loam probably predominates. Much of the soil dries out to a gray color, owing to the high alkali content. The soil material below the surface layer ranges from loose silt loam to clay of dark brownish-gray color and highly mottled. Both the surface soil and subsoil layers are intermittently calcareous.

Alviso loam occurs under conditions of very poor drainage on the floors of lagoons extending from areas of tidal marsh a few miles inland. Areas are located in all the lagoons south of Oceanside as far as the Soledad Lagoon at the southern end of the area.

Areas of the soil not under water have a cover of pickleweed and salt grass. The areas that dry out during the summer expose a bare white surface having a heavy crust of saline salts.

Alviso loam has no agricultural value except in a few places where some pasture is afforded by grasses that grow at the extreme upper part of the lagoons where the salt content is lower than elsewhere.

LAGUNA LOAMY SAND

Typically the surface soil of Laguna loamy sand consists of light-gray or light brownish-gray loamy sand which is somewhat variable in texture. The surface soil is browner and more mellow when moist, and it has a tendency to bake on drying. The subsoil consists of light-gray or light brownish-gray stratified material.

This soil occurs on steep alluvial fans where soil material is being constantly added to that already in place. Small erosion channels occur on the fans after heavy rains. These very recently deposited soils are somewhat leachy and need to be built up by the incorporation of organic matter. Areas at the upper end of the alluvial fans have subsoils heavier than typical, which hold considerable moisture. As a whole, Laguna loamy sand is well drained, and some spots occur where moisture moves through the soil too rapidly.

Almost 3 square miles of this soil occur in small scattered areas east of Cardiff, Solana Beach, and Del Mar.

Nearly all of this land is used for cultivated crops, especially beans, which are grown on more than 75 per cent of the total acreage. Peas, potatoes, and corn are grown to some extent and a few young walnut groves have been set out recently. A very small proportion of Laguna loamy sand is under irrigation at the present time.

GREENFIELD SANDY LOAM

Greenfield sandy loam consists of brown or light reddish-brown light-textured friable micaceous gritty sandy loam to a depth ranging from 6 to 14 inches. Below this layer the upper part of the subsoil is slightly more compact but typically not much heavier in texture. The subsoil is micaceous and in most places is redder than the surface soil. This soil differs from Hanford fine sandy loam in having a subsoil that is more compact, redder, and heavier in texture than the surface soil, but the subsoil is not sufficiently compact to retard the penetration of roots or moisture to a great extent. The surface relief is smooth, and the land can be easily irrigated.

Three areas occur near San Marcos that have a reddish-brown fine sandy loam surface soil which lacks the mica content of typical Greenfield sandy loam. The soil material in these bodies is derived from basic igneous rocks. It is associated with, and is outwash from, the hills occupied by the Las Posas and Escondido soils.

Large cobbles and stones from 3 to 18 inches in diameter occur over the surface and throughout the soil mass in a few small areas east of Pala. These areas are on a high alluvial fan and have not been cultivated on account of their stoniness. They are indicated on the soil map by stone symbols.

Greenfield sandy loam is scattered over the eastern half of the Oceanside area on high alluvial fans, valley floors, and in narrow valleys. More than 10 square miles are mapped The most extensive bodies are northeast of Fallbrook; east of Vista; 2 miles north, 3 miles west, and 3 miles southeast of Escondido; east of Pala; and northwest of Poway.

All crops grown in the eastern part of the area, away from the coast, are grown on this soil. Truck crops, alfalfa, and citrus fruits are grown with irrigation, and grain, walnuts, and grapes without irrigation. Some very good citrus groves are on the higher slopes of this soil north of Escondido. Manure and winter cover crops give good results in maintaining fertililty of the land.

Greenfield sandy loam, calcareous-subsoil phase.—The surface soil of the calcareous-subsoil phase of Greenfield sandy loam ranges from coarse to fine textured highly micaceous sandy loam of light grayish-brown or dull grayish-brown color. The subsoil is brownish-gray or grayish-brown calcareous sand or sandy loam beginning at a depth ranging from 30 to 45 inches. This soil occupies the lower parts of alluvial fans that have evidently been poorly drained at one time. The water-holding capacity ranges from medium to low. In the drier and warmer parts of the area this soil must be irrigated for most crops. Its surface relief is favorable for easy irrigation.

Where water is available from wells, land of this phase is used for alfalfa and truck crops on account of its favorable surface relief and depth. More than 75 per cent of this soil is cropped.

Bodies of Greenfield sandy loam, calcareous-subsoil phase, occur in Moosa Canyon, in upper San Luis Rey Valley, in San Marcos Val-

ley, south of Olivenhain, in Poway Valley, and in Escondido Valley. All the areas in San Luis Rey Valley and in Moosa Canyon are under irrigation, the water being obtained from wells adjacent to the stream channels. Acre yields ranging from 5 to 9 tons of alfalfa and large yields of vegetables are obtained where the land is fertilized and watered properly.

BOTELLA LOAMY SAND

The 10 to 15 inch surface soil of Botella loamy sand consists of dark brownish-gray or dull-gray friable loamy sand. The subsoil is of the same or of lighter-gray color, is slightly compact, and may be of slightly heavier texture than the surface soil. The compaction of the subsoil is not sufficient to hinder the penetration of roots or moisture. Included with this soil are small areas that have a rather large accumulation of clay in the subsoil. In typical Botella loamy sand more friable material is present below a depth ranging from 30 to 50 inches.

This soil absorbs moisture readily, is easy to till, has a moderate organic-matter content, and is well drained. It consists of outwash from the sandy coastal-plain terraces.

Botella loamy sand occurs on steep alluvial fans and in the bottoms of small ravines a few miles back from the coast. The larger bodies are east of Ponto, Leucadia, Solana Beach, and Del Mar, and smaller ones are east of the coast farther north.

Botella loamy sand is extensively cropped to beans, peas, corn, and grain, none of which are irrigated. Beans probably are grown on 80 per cent of the soil. A large variety of truck crops could be grown with irrigation.

Botella loamy sand, brown phase.—The brown phase of Botella loamy sand is differentiated from typical Botella loamy sand solely on the basis of its browner surface soil.

One large area on which beans and potatoes are grown at the present time is 2 miles east of Leucadia. Other areas are in La Zanja Canyon, east of Cardiff, southeast of Solana Beach, and in the canyons southeast of Del Mar.

Without irrigation, soil of this phase is used for beans, peas, potatoes, corn and general field crops. With irrigation, it could be used for a wide variety of crops. All land of the phase is now being tilled.

BOTELLA SANDY CLAY LOAM

Botella sandy clay loam is characterized by a dark brownish-gray or dull grayish-brown sandy clay loam or heavy loam surface soil which extends to a depth ranging from 8 to 20 inches. The material is very dark and sticky when wet and dries out with a hard baked surface. The surface soil rests on a very dark brownish-gray moderately compact subsoil, of similar or slightly heavier texture than the surface soil. This layer extends to a depth ranging from 30 to 50 inches where it grades into lighter-gray or grayish-brown more friable stratified soil material. Internal drainage is somewhat restricted on the flatter parts of the soil owing to the heavy character of the soil material.

Botella sandy clay loam is developed on outwash material from the coastal-plain terraces and occupies small canyons and valleys a few miles back from the seacoast. Almost 3 square miles of this soil

occur within the Oceanside area. Bodies lie along Loma Alta Creek, in a number of draws east of Carlsbad and Ponto, and northeast of Oceanside. None of this soil is irrigated at present, although the surface relief is such that the land can be easily watered.

All the land is under cultivation, mainly to beans, corn, and peas, and good yields are obtained. A few walnut groves have been set out and are doing well.

Botella sandy clay loam, brown phase.—The brown phase of Botella sandy clay loam consists of brown loam or sandy clay loam to a depth ranging from 8 to 16 inches. This layer is underlain by a lighter-brown compact clay loam subsoil containing some gravel, and this layer, in turn, rests on more friable soil material at a depth ranging from 36 to 60 inches. This soil would have been classified in a separate series had it been more extensive.

This brown soil occurs in two areas—in McGonigle Canyon 4 miles east of Del Mar and in Los Penasquitos Canyon 6 miles east of Del Mar. It occupies the flat floors of the canyons and the gentle side slopes and could be easily irrigated if water were available. All land of this phase is under cultivation to grain and beans, and good yields are obtained.

SAN MARCOS FINE SANDY LOAM

The 12 to 16 inch surface soil of San Marcos fine sandy loam is dark brownish-gray micaceous fine sandy loam. The subsoil is similar to the surface soil in color but is of slightly heavier texture, slightly compact, highly calcareous, mottled, and poorly drained. Alkali accumulations occur on most of the more poorly drained spots which have a salt-grass cover. The surface relief is flat, and the land is subject to overflow.

Two bodies mapped as San Marcos fine sandy loam, one in Poway Valley and the other 1 mile south of San Marcos, are dark gray in color and loam in texture, but otherwise they have the same characteristics as the typical soil. Both contain small quantities of alkali but are considered desirable for truck crops and alfalfa. The area near San Marcos has been tile drained and is now in alfalfa. Irrigation water is obtained from wells.

Other areas of this soil are northeast of Escondido, 6 miles southeast of Fallbrook on the Monserate ranch, along Buena Vista Creek, along Agua Hedionda Creek 4 miles southeast of Carlsbad, and 4 miles east of Ponto.

Alkali and poor drainage are the limiting factors in the utilization of this soil, and for this reason no fruit trees are grown. Alfalfa, truck crops, corn, and grain give good yields on the areas that have been drained or contain less alkali than normal, and more of the soil can be utilized when drainage conditions are improved.

SAN MARCOS LOAMY FINE SAND

Typically the surface soil of San Marcos loamy fine sand is dark brownish-gray or dull grayish-brown highly micaceous friable loamy fine sand. The soil material in this layer is very smooth and slick and has a silvery gloss, owing to the high mica content. The upper subsoil layer, extending to a depth ranging from 18 to 30 inches, is slightly compact and a little heavier in texture than the surface soil,

and the lower subsoil layer, extending to a depth of more than 72 inches, is dark brownish-gray or dark-gray calcareous very fine sandy loam, somewhat mottled with iron stains. During the rainy season the water table is usually from 3 to 5 feet below the surface, and the land is subject to overflow during heavy storms.

This soil is easy to cultivate and irrigate, but agriculture is limited by the accumulation of alkali in spots, the prevalence of a high water table, and the danger of overflow. One area covering about 2 square miles occurs at the lower end of San Dieguito Valley. Some of this area is being cultivated, and no doubt more land will be brought under cultivation in time. Truck and general field crops are grown on the cultivated spots with good results.

SALINAS CLAY LOAM

Where typically developed, the surface soil of Salinas clay loam consists of dull grayish-brown or dull brownish-gray clay loam of somewhat sandy texture. It is underlain by an upper subsoil layer, extending to a depth ranging from 30 to 48 inches, that is of similar, or slightly lighter, color and slightly more compact than the surface soil. This layer is underlain by a somewhat lighter brownish-gray lower subsoil layer consisting of calcareous clay loam or clay, and extending to a depth of more than 6 feet. The soil material of Salinas clay loam is of mixed origin.

Salinas clay loam occupies small valleys in the coastal-plain region and is one of the best dry-land bean soils of the area, owing to its high moisture-holding capacity, general fertility, and depth.

Three small bodies of dark-gray clay are included with this soil as mapped. These bodies are similar to the typical soil, except in color and their heavier texture. They occur 3½ miles east of Oceanside, 2½ miles northeast of San Luis Rey Mission, and one-half mile north of Escondido, respectively. The surface soil in these areas is somewhat harder to till because of its heavier texture.

Two small bodies having a dark-gray calcareous clay surface soil and a dark-gray calcareous subsoil were mapped—one, one-fourth mile south of San Luis Rey Mission and the other 4 miles east of the mission. The area south of the mission has a water table close to the surface and has not been used for crops, but the other area is highly prized for vegetables and general crops.

Typical areas of Salinas clay loam occupy small valleys a few miles east of Oceanside, Carlsbad, and Ponto. Acre yields of 10 sacks of Lima beans have been obtained in seasons of sufficient rainfall.

RAMONA SANDY LOAM

The surface soil of Ramona sandy loam is brown friable sandy loam of rather fine texture. At a depth ranging from 12 to 20 inches this material rests on reddish-brown moderately compact clay loam or sandy clay loam. Below this and extending to a depth ranging from 40 to 60 inches, is dull reddish-brown compact sandy clay loam. The soil material below this layer is loose, of variable texture, and brown or yellowish brown in color. All layers contain soil material of granitic origin. This soil occurs on flat or gently sloping terraces scattered over the granitic back country and is well drained and easy to irrigate. Where water is available for irrigation this is considered

a highly desirable soil for a wide range of crops, including citrus fruits in frost-free locations. In the Escondido district, grapes are grown on the lower slopes and citrus fruits on the warmer spots.

In the western part of Poway Valley and in Green Valley bodies of this soil occur that differ from the typical soil in that they are underlain at a depth ranging from 2 to 5 feet below the surface by granitic bedrock or a gravelly cemented substratum. Had these areas been more extensive they would have been mapped as a shallow phase of Ramona sandy loam. They are used for growing grain, grain hay, and grapes, but with irrigation a wider variety of crops could be grown.

Ramona sandy loam is most extensively developed in Escondido and Poway Valleys, and a large number of small areas are south and east of Bonsall and east of Fallbrook. Nearly all of this soil is farmed, as it is a highly desirable soil for a wide range of crops with irrigation. The moisture-holding capacity of the soil and the organic content can be increased by turning under organic manures and plant residues.

Ramona sandy loam, stony phase.—The stony phase of Ramona sandy loam has the same soil characteristics as typical Ramona sandy loam and in addition has a quantity of granite stones, ranging from 4 inches to 2 feet in diameter, scattered over the surface and through the soil mass to some extent. Three bodies of the phase occur in the Oceanside area—one in the western part of Poway Valley and the other two on the stony alluvial fan 2 miles east of Pala. They are covered by low desert brush and are used only for pasture. If cleared of surface stone, land of the phase would have the same agricultural possibilities as typical Ramona sandy loam.

MERRIAM SANDY LOAM

The 8 to 16 inch surface soil of Merriam sandy loam consists of brown or reddish-brown friable sandy loam of rather fine texture but containing much coarse sharp gritty sandy particles. It is abruptly underlain by dark brownish-red very compact sandy clay or clay, which breaks into medium-sized cubes when dry. The upper subsoil layer limits the penetration of roots and moisture. Between depths of 28 and 40 inches, in the lower part of the heavy clay, accumulated lime occurs in nodular form or as small light-colored specks and veins. At a depth ranging from 36 to 50 inches this layer rests on dark-brown moderately compact loam or sandy loam, which is of lower lime content or noncalcareous. The surface soil is friable, except where it is allowed to dry when not cultivated. Normally the subsoil holds up water after heavy rains so that the surface soil is water-logged. This condition is especially evident in some of the flatter areas where the surface has a "hog-wallow" relief, consisting of small mounds and depressions In the depressions the heavy subsoil is close to the surface.

Merriam sandy loam occurs in numerous bodies throughout the eastern mountainous parts of the area, mostly along valley margins or in intermountain basins. The largest bodies occupy fairly extensive areas in Escondido, Green, San Pasqual, and San Marcos Valleys, where the land is being used for grapes, hay, and grain. Some of it is under irrigation. Other areas occur south of Morro Hill,

east of Vista, on slopes bordering San Luis Rey River, and in scattered patches east of Fallbrook.

The utilization of this soil is governed largely by the character of the subsoil, and care must be used in irrigating, owing to this factor. Muscat grapes probably comprise the most important crop on Merriam sandy loam. They are grown largely without irrigation in the Escondido district.

MERRIAM FINE SANDY LOAM

Merriam fine sandy loam has a surface soil, ranging from 8 to 16 inches in depth, consisting of brown or light reddish-brown fine sandy loam which is friable when moist but bakes hard on drying when not cultivated. The surface soil rests on very compact dull reddish-brown clay that extends to a depth ranging from 40 to 60 inches. A nodular concentration of lime occurs in the lower part of the clay layer. The soil material below the clay layer is lighter in texture, although fairly dense.

This soil occurs on old alluvial fans north of San Marcos and east of Buena, where it is associated with the Escondido and Las Posas soils and is largely of basic igneous-rock origin, although somewhat mixed. Bodies also occur along the border of San Dieguito Valley, on smooth terraces along San Elijo Lagoon, and small bodies are scattered over the area.

About 4½ square miles of Merriam fine sandy loam are mapped in the area surveyed. The part within the Vista irrigation district is being planted to a variety of irrigated crops. Most of the unirrigated land is used for grain, grain hay, and grapes. Beans and other field crops are grown in years of high rainfall.

Merriam fine sandy loam, clay phase.—The clay phase of Merriam fine sandy loam has a surface soil consisting of rich reddish-brown clay, and the subsoil is similar to that of typical Merriam fine sandy loam. This soil is not extensive, only small scattered bodies occurring on gentle slopes at the foot of hills. A fairly wide variety of crops is grown where the soil is irrigated, although the land is hard to handle, owing to its heavy texture and stickiness.

One body of the clay phase which is in reality a clay loam, occurs 1 mile north of Richland. This body is planted to grapes at the present time.

HUERHUERO FINE SANDY LOAM

Huerhuero fine sandy loam is characterized by a light brownish-gray or dull brownish-gray fine sandy loam surface soil, ranging in depth from 8 to 16 inches. The subsoil is dull grayish-brown compact sandy clay or sandy clay loam, the lower part of which in many places is lighter textured and calcareous, the lime carbonate occurring as seams and soft nodules. The calcareous zone ranges from yellowish brown to gray in color and extends to a depth ranging from 48 to 60 inches. The soil material below the calcareous zone consists of yellow or gray stratified sediments.

This soil is low in organic matter and, in most places, low in fertility which can be built up by the incorporation of organic manures and plant residues. When loose the surface soil absorbs moisture readily, but the subsoil retards the penetration of moisture.

One body of this soil 2½ miles southeast of Carlsbad along Agua Hedionda Creek has a surface soil of clay loam. This body is used for grain, and fair to low yields are obtained. In years of sufficient rainfall, beans are planted.

Most of the Huerhuero fine sandy loam occurs on flat-topped or gently sloping marine terraces along the edges of the lagoons and stream valleys, which extend back from the sea. Higher terraces of this soil are northwest of Vista and south of Buena.

Because of its favorable position, most of the land has at one time been farmed, although poor yields have been obtained. At present more than 90 per cent of the land is not under cultivation, although most of it would be planted to grain or beans in a favorable year of high prices and good rains.

REDDING GRAVELLY SANDY LOAM

Redding gravelly sandy loam has a 6 to 14 inch surface soil consisting typically of light brownish-red or pronounced reddish-brown gravelly sandy loam, but it includes, as mapped, extensive areas in which both surface soil and subsoil materials contain large quantities of large waterworn stones. The stony areas are indicated on the soil map by stone symbols.

In areas in which the larger stones are lacking, the quantity of gravel varies, although in most places it comprises more than 25 per cent of the soil mass. The gravel are rounded and range in size from small gravel to cobbles 3 or 4 inches in diameter, in most areas being of such size and quantity that the soil can not be easily cultivated. The subsoil is very compact reddish-brown sandy clay that does not contain quite so many cobbles as the surface soil. This layer rests, at a depth ranging from 14 to 30 inches, on a layer of pale brownish-red or reddish-brown cobbly hardpan. (Pl. 3, A.) The hardpan may be several feet thick and is, in turn, underlain by a bed of compact and more or less cemented gravel and cobbles.

In the stony areas more than 50 per cent of the soil mass consists of rounded stones of mixed geologic origin, ranging in size from 2 to 8 inches in diameter. It is impossible to till this soil until the stones have been removed from the surface. The subsoil is dark chocolate-brown compact gravelly stony clay which is extremely tight and cheesy and ranges from 8 to 16 inches in thickness. Below this, and extending to a great depth, is a mass of compact cemented gravel and cobbles.

Two included areas, one occurring 3 miles east of Olivenhain and the other 4 miles southwest of San Marcos, differ from typical Redding gravelly sandy loam in that they have no accumulation of red clay in the subsoil. Both bodies have a gravelly substratum composed of angular rock fragments. They have received some wash from the adjacent hills and the soil is deeper and somewhat browner than typical. It is a better soil than typical Redding gravelly sandy loam and is being used for dry-farmed grain hay.

A number of stony areas along the south edge and at the west end of Poway Valley also differ from the typical soil, being dark gray in color and of clay loam or clay texture. They occur on lower slopes where there is seepage. This darker-colored soil contains less

stone, has a good grass cover, and is a much better soil agriculturally than typical Redding gravelly sandy loam.

The most extensive occurrence of the less stony areas of Redding gravelly sandy loam is on the broad mesa 7 miles southeast of Del Mar. Isolated areas, remnants of the same flat-topped mesa, occur 2 or 3 miles north of the main area. The large area on the Miramar Mesa extends out of the Oceanside area southward toward San Diego, where it is more extensive. One area near the southern boundary of the area surveyed, about three-fourths of a square mile in extent, has a brownish-gray surface soil. In the stony areas, which occur on high eroded mesas northeast, east, and southeast of Black Mountain, little is left of the original surface soil except long narrow ridges which occur at an elevation ranging from 800 to 1,000 feet above sea level. Most of the associated eroded slopes have been mapped as rough broken land.

The Miramar Mesa is cut by a number of intrenched canyons and ravines. Here very little erosion is taking place on the surface, as most of the land is at the heads of the ravines. The surface is covered by "hog-wallow," mounds and depressions in which the rainfall is caught and retained by the impervious substratum. This results in a boggy condition of the surface soil during the rainy season.

This soil has a thick cover of chamiso. (Pl. 3, B.) Attempts have been made to farm spots of this soil, but with very little success. Hay and grain have been grown on a small acreage where the soil contains less gravel and stone and is deeper than typical, but the yields were light. Certain shallow-rooted crops could probably be grown if water for irrigation were available and care used in applying it, but there is little or no water supply and the surface relief is, in general, unfavorable for irrigation. Little of the soil is in use at present except as pasture

MONSERATE SANDY LOAM

The surface soil of Monserate sandy loam is brown sandy loam, ranging in depth from 8 to 16 inches. The plowed surface soil in many places presents the appearance of a redder and heavier-textured soil, because the subsoil is turned up in the shallower spots. The surface soil is also heavier in spots where erosion has taken place. The upper subsoil layer, extending to a depth ranging from 24 to 40 inches, is very compact chocolate-brown sandy clay. Below this is a layer of brown sandy clay, mottled with nodules and spots of lime. This layer rests directly on a reddish-brown iron and silica cemented hardpan that contains lime seams and coatings. The hardpan is variable in depth and thickness, and not everywhere continuous. It is underlain by grayish-brown sandy loam, or other variably textured sediments which typically are noncalcareous, but which include seams of lime accumulation in the extreme southern part of the Oceanside area and extending into the El Cajon area on the south.

Monserate sandy loam occurs on gently sloping terraces, where surface drainage is good but subdrainage is restricted by the heavy clay layer and the hardpan. These same factors restrict the growth of deep-rooted crops.

The larger areas of Monserate sandy loam occupy terraces on the Monserate grant northeast of Bonsall. Three small areas occur southeast of San Marcos and one small body is on the southern boundary of the area. Most of this soil has been used for pasture. Where water has been pumped on the Monserate ranch, truck crops are growing, but yields are much lower than those obtained on the deeper soils of the valley floor.

ROUGH STONY LAND

Rough stony land consists of stony areas of steep and stony surface relief covering nearly 25 per cent of the Oceanside area. This land is typically nonagricultural, owing to its rough mountainous relief and its stony character. In most places stones ranging from 2 to 10 feet in diameter are scattered over the surface, either as loose stones or as rock outcrops.

The largest areas of rough stony land are east of Fallbrook, throughout the Merriam Mountains, around Mount Whitney and Black Mountain, and east of Escondido. Most of the soil material between the rocks is a granitic sandy loam of the Vista or Fallbrook series.

Little pasturage is obtained on this land, as the stones are numerous and the growth of grasses is restricted. Part of the rough stony land supports a brush growth.

ROUGH BROKEN LAND

Rough broken land includes areas that are nonagricultural because of their steep, broken, or eroded surfaces. In the Oceanside area, rough broken land is largely confined to the steep broken slopes descending from the mesas of the coastal plain. Unlike rough stony land the surfaces and slopes are typically fairly free of stone. It also includes the slopes of the deeply intrenched valleys of the streams flowing down from the mountains. Rough broken land in this area includes a wide range of soil material, from the eroded subsoil of the Las Flores soils to the red gravelly soils of the Redding series. South of Poway Valley, rough broken land contains rounded cobbles on the surface. The area occupied by rough broken land is excessively drained and subject to erosion.

Brush and grass grow on slopes where there is soil, and these areas are used for pasture. Rough broken land is much less extensive than rough stony land.

TIDAL MARSH

Tidal marsh in the Oceanside area consists of low-lying areas, traversed by tidal sloughs, which are periodically covered with salt or brackish waters. At the mouths of the larger streams the soil material is sandy, but the material in the flatter lagoons, such as Batiquitos Lagoon and Agua Hedionda Creek, is sticky clay.

Areas of tidal marsh occur at the lower ends of Batiquitos Lagoon, Agua Hedionda Creek, Buena Vista Creek, Loma Alta Creek, and San Luis Rey Valley. Most of the areas are separated from the sea by a strip of coastal beach and dune sand, and they would be expensive to reclaim, owing to the danger of overflow by drainage from the back country, as well as the expense of putting in tidal

gates and the construction of levees. Tidal marsh has no value for agriculture until diked and drained.

RIVER WASH

River wash of the Oceanside area comprises the sandy material in the beds of the present channels of rivers and streams or in channels which have been abandoned by the streams only within recent years. The material ranges in texture from fine sand to coarse gravel, has a very low organic content, and supports a growth of brush and willows where the sand is finer textured and where sufficient water from the channel percolates through the sands.

Bodies of this material occur along San Luis Rey River, in Moosa Canyon, along San Dieguito River above Hodges Reservoir, in San Dieguito Valley south of Rancho Santa Fe, and along Los Penasquitos Creek. River wash is of unfavorable texture and is subject to overflow during flood periods. A few areas are used for pasture, but most of the land is of no agricultural importance.

COASTAL BEACH AND DUNE SAND

Coastal beach and dune sand includes areas of materials differing somewhat in surface relief but having similar soil material. Coastal-beach areas occur as a narrow marine beach margin along the ocean front, and dune-sand areas usually adjoin the beach as a parallel zone of wind-blown sand swept in from the beach. The soil material of dune sand is light grayish-brown or brownish-gray uniform sand more than 6 feet deep. Both classes of material are very low in organic matter and of low water-holding capacity. Most of the more extensive areas of dune sand are at the mouths of the various lagoons where the sand acts as a barrier. This sandy material extends along the entire coast line, but in places the areas are too narrow to show on the map. The land is nonagricultural.

IRRIGATION

The mission fathers early realized the need for supplementing the rainfall of the region by the artificial application of water. One of the early reports of the San Luis Rey Mission, in 1822, stated that crops had been poor for many years, owing to the lack of rain, so ditches were constructed at San Luis Rey and Pala to bring water for the crops in the vicinity of the missions.

Pumping has been carried on in San Luis Rey Valley for the irrigation of alfalfa and general field and truck crops for a long time. Centrifugal and deep-well turbine pumps are used for lifting water from the water-bearing gravel below the bed of the river. These extend down the river from Pala to Oceanside.

The Escondido irrigation district was organized in 1889 to obtain water for Escondido Valley. This was taken over in 1905 by the Escondido Mutual Water Co. which serves water at the present time to lands in the valley. Water has been provided from Henshaw Reservoir for about 3,200 acres of land that are suitable for irrigation. Water costs from $17.25 to $24.50 an acre-foot, depending on the kind of water stock held. For the irrigation of citrus orchards in this district, the yearly water costs run from $30 to $35

an acre. About 2,500 acres of citrus orchards are under the system of the Escondido Mutual Water Co.

Land in the Fallbrook territory is included in an irrigation district, but as yet water has not been obtained. Citrus fruits in this district are now watered from wells in the ravines. The acreage handled by these wells is small, as each well covers only a few acres of land.

The development of water for land on the coastal plain of the area was the impetus that started urban development, avocado culture, and flower and truck crop culture, as they exist to-day. The Oceanside Mutual Water Co. was organized in 1914. It obtains water from deep wells in San Luis Rey Valley and distributes the water over the district south of Oceanside and Carlsbad as far as Agua Hedionda Creek. About 1,500 acres are being watered by this system, including approximately 400 acres devoted to young avocados and the rest to mixed truck crops and flowers. The company reports a duty of 1.5 acre-feet to the acre, at a yearly cost of approximately $30 an acre. All young orchards are intercropped with truck crops the year round.

Land in the vicinity of Vista is served by the Vista irrigation district. Water was obtained from Henshaw Dam in 1926, and the cost is $17.50 an acre-foot annually, plus interest charges on the bonds which amount to $8 an acre, and the charge for operation and maintenance of the system amounts to $4 an acre.

The Rancho Santa Fe and the San Dieguito irrigation districts serve the coast territory between San Elijo Lagoon and San Dieguito Valley and back of Solana Beach to a point about 1 mile east of Rancho Santa Fe. The land in both districts is bonded for the construction cost. Water is purchased from the city of San Diego and conveyed from Hodges Reservoir to the lands to be irrigated. Each acre in the districts has a water right of 1 acre-foot a year. Citrus orchards predominate in the Rancho Santa Fe district, and avocados and flowers are grown most extensively along the coast. Water costs between $20 and $30 an acre per annum, including all charges. About 3,500 acres are under irrigation in the two districts. Water was first delivered late in 1923.

Deep wells in San Dieguito Valley pump water for land in the valley and for citrus orchards on the hills east of the valley. Alfalfa is irrigated in San Pasqual Valley with water from deep-well pumps.

Alfalfa is irrigated by means of running the water down the slope between two borders or levees. For orchards and row crops, the furrow system is used. A rather large acreage of avocados, citrus fruits, flowers, and other crops is being irrigated by means of overhead sprinkling systems. This system applies the water uniformly, no furrows are needed, and the labor cost is small, once the system is installed. The initial cost of installing such a system is high, yet the overhead sprinkling system is well adapted to the sandy soils along the coast and affords efficient irrigation.

SOILS AND THEIR INTERPRETATION

The Oceanside area is located in the Pacific coast soil region of southern California. The soils range in color from light gray to brown and black, but the predominant color is brown.

A, Profile of Redding gravelly sandy loam, showing cemented hardpan substratum with embedded gravel and cobbles, B, typical chamiso brush vegetation on Redding gravelly sandy loam

Detailed descriptions of the soils identified in the area, arranged according to the maturity of the profile and the kind of rock from which the material was derived, serving as a scientific record of the investigations carried out in the area, given without reference to the agricultural or other economic value of the soils, are contained in the following pages.

SOILS DEVELOPED ON NONCALCAREOUS BEDROCK

The soils in this group are underlain at a depth of less than 6 feet by hard bedrock composed of granite, diorite, schist, and quartzite. They occur in the rolling or mountainous district back from the coastal plain in a region receiving from 14 to 20 inches of annual rainfall, where a fairly good growth of native grass springs up in the winter but soon dries in the early summer. Associated with this group at elevations ranging from 500 to 2,000 feet above sea level are large mountainous areas of rough stony land. Soils included in the group are members of the Vista, Fallbrook, Las Posas, Konokti, Escondido, and Carlsbad series. Physiographically, the soils of the Carlsbad series occur on the coastal plain, but they are placed in this group of soils on the basis of their profile characteristics.

The Vista, Fallbrook, Las Posas, and Konokti soils all have a more or less definite B horizon of accumulated clay developed above the bedrock. This heavy horizon does not occur in the soils of the Escondido series, in which the surface soils extend to the shattered bedrock with no visible compaction, clay accumulation, or structural differences.

A typical development of Las Posas stony fine sandy loam has a surface layer, extending to a depth ranging from 2 to 4 inches, of dark brownish-red friable stony fine sandy loam soil of granular structure and heavily impregnated with roots and organic matter. This layer has a pH value ranging from 6.3 to 6.6. The soil material between depths of 4 and 16 inches is red or dark-red slightly compact stony fine sandy loam or loam full of root cavities. The material in this layer breaks up into a coarse granular or cloddy structure. The pH value of this layer averages about 7. The B_2 layer, extending between depths of 16 and 26 inches below the surface, is plastic and compacted stony fine sandy loam or loam which breaks up into a cloddy structure, and which shows a rather large number of root cavities. This layer has a pH value ranging from 7.02 to 7.12. Shattered bedrock occurs at a depth of 26 inches.

Determinations of the pH values of Fallbrook fine sandy loam give about the same results as those obtained for the Las Posas soil. A typical area of Fallbrook fine sandy loam shows the following profile:

From 0 to 10 inches, light brownish-red or dull brownish-red friable fine sandy loam having a pH value ranging from 6.6 to 7, micaceous, and full of root and worm cavities.

From 10 to 24 inches, dull-red or red slightly compact fine sandy loam or loam, breaking up into medium-granular or cloddy structure, full of root and worm cavities, having much dark staining on the surfaces of the broken fragments, and having a pH value ranging from 7 to 7 2 Fine-textured granitic rock fragments occur at a depth of 24 inches

The Carlsbad soils are different from the other soils in this group in many respects. A typical area of Carlsbad loamy fine sand shows the following profile:

From 0 to 12 inches, pale reddish-brown or light grayish-brown friable loamy fine sand, in which iron pellets ranging from one-eighth to one-fourth inch in diameter occur throughout the soil mass. Roots are well distributed in this horizon.

From 12 to 30 inches, brown or reddish-brown moderately compact loamy sand, containing very few root cavities. The material is mottled gray and brown in the lower part of the horizon. Iron pellets occur throughout the entire horizon.

From 30 to 50 inches, the pale brownish-red partly consolidated substratum of sandstone.

The Carlsbad soils occur on the tops of sandy sea terraces, at an elevation ranging from 200 to 300 feet above sea level, at a distance ranging from 1 to 3 miles back from the shore line. The slopes and edges of these terraces have been eroded, exposing the C horizon which resembles hardpan in many respects.

SOILS DEVELOPED ON CALCAREOUS OR INTERMITTENTLY CALCAREOUS BEDROCK

The soils in this group are underlain at a depth ranging from 2 to 4 feet by consolidated material that is intermittently calcareous in the soils of the Altamont series and highly calcareous in the Diablo, Ayar, and Linne soils.

The surface soils of members of the Ayar and Linne series are calcareous and the surface soils of members of the Diablo and Altamont series are noncalcareous. The bedrock, or C horizon, underlying the Diablo, Ayar, and Linne soils is highly calcareous sedimentary shale or limestone. The Ayar and Altamont soils are brown, whereas the Diablo and Linne soils are dark gray or nearly black.

Soils of this subgroup occur on high benches and slopes of the coastal plain at an elevation ranging from 200 to 500 feet above sea level. The soils are intermediate in position between the soils of the coastal plain and the soils of the mountainous districts.

SOILS DEVELOPED ON PARTLY CONSOLIDATED MARINE SEDIMENTS

In this group are included those soils having heavy waxy clay subsoils (B horizons) and partly consolidated substrata (C horizons). They are developed on the coastal-plain physiographic division of the area, from 1 to 8 miles back from the shore line, at an elevation ranging from 50 to 500 feet above sea level, on badly eroded sea terraces that have undergone uplift and depression, accompanied by erosion and deposition, since being laid down by water. These badly eroded terraces slope westward from the highlands to the sandy area along the coast. Included in this subgroup are the members of the Tierra series with dull brownish-gray surface soils, the members of the Las Flores series with light-gray surface soils, and the members of the Olivenhain series with brown surface soils. They occur under a rainfall ranging from 8 to 14 inches.

Aside from the color of the surface soil, the profiles of the soils of these three series are very similar. A detailed description of Olivenhain loamy fine sand is given as representative of the subgroup, and differences from the other two soils are pointed out.

From 0 to 9 inches, brown or light pinkish-brown friable loamy fine sand that is slightly granular although it is easily broken into a powdery mass. The soil becomes redder when moist. This horizon is well filled with roots which extend down to, and mat themselves over the top of, the heavy clay horizon. A thin layer of light-gray fine sandy loam rests on top of the horizon below.

From 9 to 27 inches, dark-brown or dark reddish-brown very compact waxy clay that breaks up to a columnar structure when dry. The tops of the columns are slightly rounded, and the columns are from 1 to 2 inches in diameter and from 4 to 7 inches in length. The line between this and the horizon above is very abrupt and sharp. The lower part of this horizon breaks to a cubical structure and is a little lighter colored. Colloidal coating occurs on the outsides of the soil fragments when they are broken but not throughout the soil mass when broken across the cleavage lines. When powdered into a fine mass the color appears lighter. Roots extend along the cracks. Alkali tests show a sodium-chloride content ranging from 20 to 100 parts per million in this horizon.

Below 27 inches, moderately consolidated sediments, ranging from brown or gray to yellow in color and of variable texture. Alkali determinations, made by means of the Wheatstone bridge, show approximately 0.2 per cent of alkali in the substratum.

Both the Las Flores and Tierra soils show the same structural properties as those occurring in the Olivenhain soils. The heavy clay horizon in the Las Flores and Tierra soils is duller in color than that of the Olivenhain soil and contains more sandy material. The subdrainage of these three soils is restricted by the compact clay horizon.

SOILS DEVELOPED ON UNCONSOLIDATED MATERIALS WITH PROFILES SHOWING NO WEATHERING

Included in this group are those soils that are so young that they lack any structural development or horizons of compaction. They include recent soil material built up so fast that it has not been altered by weathering.

These soils occur in the stream valleys and on the alluvial fans and flood plains scattered over the area and are either in the process of being deposited or have been recently deposited. In the Tujunga soils the soil material is still in the process of being deposited, whereas in the related Hanford soils the soil material has been deposited long enough for humus to accumulate in the surface soil but not long enough for the downward migration of clay to take place under these climatic conditions. Both the Tujunga and Hanford soils are highly micaceous, the soil material being largely from granitic sources. The soils of the Foster series occur in the flatter, more poorly drained valleys where the water table is high. They are calcareous, as well as highly micaceous. The soils of the Laguna series are made up of recently deposited light-gray or light brownish-gray soil material. The surface soil material of the members of the Alviso series is dark brownish gray, in many places is calcareous, and contains a large quantity of salts. The subsoil material is highly mottled, owing to poor drainage conditions.

SOILS DEVELOPED ON UNCONSOLIDATED MATERIALS WITH YOUNG OR MODERATELY DEVELOPED PROFILES

Included in this group are the soils having some compaction and a slight accumulation of clay or lime in the subsoils. They represent a stage in soil weathering intermediate between soils of the recent and

immature groups. The Greenfield, Elkhorn, and Botella soils are noncalcareous, and the soils of the San Marcos and Salinas series have calcareous subsoils.

The Greenfield soils represent a stage in weathering between the Hanford and Ramona soils. The subsoils of these soils are slightly more compact and richer in color than the surface soils and have acquired a small amount of accumulated clay. The soils of all three series contain a large amount of granitic material in their profiles. The Greenfield soils occupy a very similar topographic position to the Hanford soils, on sloping alluvial fans.

The Botella soils are darker colored than the Greenfield soils and are made up of soil material of mixed mineralogical origin; otherwise the typical profile has about the same degree of compaction and clay accumulation.

The Elkhorn soils have been weathered on a sandy marine terrace where the soil material contained little clay to be carried into the subsoil. The surface soils are sandy, and brown in color, with gray streaks extending downward along root cavities to a depth ranging from 12 to 16 inches. The B horizon bakes hard on drying but is fairly soft when moist, although water penetrates the lower part of the subsoil with difficulty. The lower subsoil material is mottled with gray and brown stains. Determinations showed a pH value of 6.5 for the lower part of the A horizon and of 7.9 for the lower part of the B horizon. Only a few root cavities are present below a depth of 16 inches from the surface.

The accumulation of lime in the B_2 layer of the Salinas soils is a product of soil weathering, the lime occurring in small seams and nodules and not diffused throughout the soil mass. The B_1 layer is slightly more compact than the surface soil and breaks up to a coarse granular structure. Both surface soil and subsoil are well filled with roots and root cavities. Both Salinas and San Marcos soils are dark grayish brown or dark brownish gray, but the San Marcos soils are highly micaceous, poorly drained, and contain alkali in appreciable quantities. The B_2 layer of the San Marcos soils is highly calcareous and mottled with rust-iron and black spots, owing to the high water table.

SOILS DEVELOPED ON UNCONSOLIDATED MATERIALS WITH PROFILES OF MODERATE OR FULL MATURITY

Immature or semimature soils in this group are represented by the members of the Ramona, Merriam, and Huerhuero series. The Ramona soils have a less mature profile than the other two soils. In age, the Ramona soils are between the Greenfield and Merriam soils, but all of them have soil material derived largely from granitic sources. Both the Merriam and Huerhuero soils have an accumulation of lime in the lower part of the heavy clay layer and more friable soil material below this.

The Monserate and Redding soils are characterized by fully mature profiles typical of mature weathering action under semiarid climatic conditions and by the formation of hardpan layers at a depth ranging from 18 to 36 inches below the surface.

The Huerhuero, Monserate, and Redding soils occur on terraces or mesas where the surface is marked by "hog wallows," and the

Ramona and Merriam soils occur on benches in many places, although most of the bodies occupy lower terraces and valley floors in the eastern part of the area. The "hog wallow" surface relief is in evidence over most areas of the Merriam soils but absent from areas of the Ramona soils. The surface soil of the Merriam, Huerhuero, and Redding soils is boggy during the rainy season, the heavy subsoil holding the water on or near the surface in the flats or depressions.

The soils of the Ramona series, the youngest member of this group, show the following horizons:

A. From 0 to 5 inches, brown friable sandy loam of granular structure and well filled with roots and root cavities. The coarse particles consist of granitic fragments.

B_1. From 5 to 14 inches, rich-brown slightly compact amorphous sandy loam of medium-granular structure and well filled with root cavities, in which the quartz rock fragments are easily seen by the naked eye.

B_2. From 14 to 30 inches, reddish-brown moderately compact loam or sandy clay loam, which breaks up into soil fragments the size of a walnut. Dark brownish-red glazing appears on the faces of the fragments, but no glazing on the broken surface of fragments. Small holes occur throughout the soil mass, and the material has a large content of quartz particles.

B_3. From 30 to 50 inches, dull reddish-brown or chocolate-brown compact sandy clay loam or sandy clay, which breaks up into irregular or cubical shaped clods from 1 to 2 inches in diameter. The structure is somewhat columnar in exposed cuts. Dark brownish-red colloidal glazing occurs on the surfaces of clods and dark stains in root cavities. The interior of the clods is browner than the exposed surface of the cubes, and the colloidal glazing extends into the inside of the cubes. The material contains a large number of quartz particles.

C_1. From 50 to 72 inches, brown or yellowish-brown slightly compact amorphous sandy loam or loam containing large particles of quartz and granitic fragments.

The Merriam soils, which represent advanced weathering of old alluvial deposits of granitic origin, show the following typical profile in the Oceanside area:

A. From 0 to 12 inches, brown friable sandy loam of fine-granular structure, showing light-gray spots on clods when broken. A ½-inch surface layer shows a pH value of 7.2, and the lower part of the horizon gives a pH value of 6.5. The soil material contains root cavities.

B_1. From 12 to 18 inches, dark brownish-red or dark reddish-brown very compact sandy clay (solonetz), with a columnar structure. The columns are about 2 inches in diameter and can be broken down into cubes that show colloidal coating on the surface, which does not persist on the inside of the cubes. Considerable dark staining is in evidence in this layer. The contact between this layer and the one above is very abrupt, and some gray coloration is on the upper surface of the columns which are slightly rounded. Root cavities are not present in this layer.

B_2. From 18 to 28 inches, brownish-red compact sandy clay of cubical structure and having less colloidal coating than the particles in the layer above. This layer is not so dark as the one above, but has dark stains in spots. The material in this layer shows a pH value of 7.6.

B_3. From 28 to 40 inches, dull-brown or dark reddish-brown compact sandy clay loam of cloddy structure, with lime, which is hard to distinguish in places, occurring in seams and small nodules. The soil material in this layer gives a pH value of 8.6. Immediately below the zone of lime concentration the soil changes in texture and structure and contains dark stains.

C. From 40 to 72 inches, dark-brown or dark reddish-brown moderately compact fine sandy loam of medium-granular structure and containing considerable dark staining.

All horizons are gritty, the soil particles being sharp and of granitic origin.

The soils of the Huerhuero series have a sequence of layers and general structural characteristics similar to the Merriam soils, but they differ in color and origin of the soil material. The following profile shows:

A. From 0 to 12 inches, light brownish-gray or light grayish-brown friable fine sandy loam, the topmost part of which packs fairly hard but breaks up readily into a granular structure. This horizon is full of root cavities, with gray coatings and streaks along the cavities. The material shows a slightly acid reaction with Teskit. A gray dusty coating occurs between this and the horizon below.

B_1. From 12 to 20 inches, dull grayish-brown very compact sandy clay loam or clay (solonetz) containing vertical columns about 2 inches wide, which break down into cubes. There is some colloidal coating on the cubes but not so much as in other soils having the characteristic solonetz structure. The line of demarcation between this horizon and the one above is sharp. The material contains small root cavities whose surfaces are darker than the soil mass. This darker color is also in evidence along the surfaces of cracks. The light-gray coating that occurs on the top of this layer extends in streaks into the layer to a depth of 1 or 2 inches.

B_2. From 20 to 32 inches, dull grayish-brown or yellowish-brown compact sandy clay loam or clay of cubical structure This layer is somewhat lighter colored and lacks the vertical breakage of the one above it

B_3. From 32 to 52 inches, yellowish-brown, mottled with red and yellow, moderately compact fine sandy loam of granular structure, with lime concentration in cracks and cavities.

C. From 52 to 72 inches, yellow or gray stratified sandy loam This material is noncalcareous and structureless.

The soils of the Monserate series have an iron and silica cemented hardpan. The mature profile is as follows:

A. From 0 to 10 inches, brown sandy loam which is hard when dry but breaks up readily into a medium-granular structure and contains a large number of small root cavities.

B_1. From 10 to 28 inches, brown or chocolate-brown very compact sandy clay that appears in columns when viewed in a cut, but breaks down readily into cubes. The tops of the columns are slightly rounded and have a slight accumulation of gray dust between them and the surface horizon. The surface of the cubes is coated with a colloidal glazing. This does not appear when the cubes are broken and the surface cracked. The lower part of this layer does not have so much colloidal glazing or as definite cubical structure as the material at the top of the layer.

B_2. From 28 to 33 inches, brown compact sandy clay loam mottled with lime.

B_3. From 33 to 70 inches, reddish-brown iron and silica cemented hardpan with lime occurring in seams and cracks. The hardpan is somewhat broken up and irregular in depth and thickness.

C. From 70 to 100 inches, grayish-brown loose stratified sand, from granitic and somewhat mixed sources, which lacks structure.

Redding gravelly sandy loam, as mapped in this area, shows the following profile:

A. From 0 to 7 inches, light brownish-red or dull brownish-red gravelly sandy loam which has a granular structure and is filled with roots. A fibrous mass of moss covers the surface. The immediate surface soil gives an acid reaction with Soiltex.

B_1. From 7 to 18 inches, dull brownish-red or red compact waxy sandy clay which breaks up into ½-inch granules when crumbled in the fingers. In a cut this material appears as irregular-shaped somewhat columnar blocks. The lower part of this layer has much colloidal glazing throughout the soil mass even on the broken granules. The color is fairly uniform and there are few root cavities

B_2. From 18 to 50 inches, pale brownish-red iron and silica cemented cobbly hardpan.

C_1. From 50 to 80 inches, a very compact, partly cemented bed of cobbles and sand, ranging from brown to gray in color.

Mechanical analyses, including determinations of the ultra, or finer, colloidal clay materials and moisture equivalents, of representative samples of soils of the Oceanside area were made in the laboratories of the division of soil technology, University of California, and the results are shown in Table 3.

TABLE 3.—*Mechanical analyses of several soils from the Oceanside area, Calif.*

Soil type and sample No	Depth	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay[1]	Colloid[2]	Total clay	Moisture equivalent
Vista sandy loam	*Inches*	*Per ct.*	*Per ct.*	*Per ct*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct*	*Per ct.*	*Per ct*
577512	0 to 2	8.1	14 4	6 8	25 3	24.7	13 2	3 9	3.9	7 8	13 2
577513	2 to 16	9 1	12.8	6 5	24.3	26.4	12 8	3.1	5 3	8.4	10 9
577514	16 to 36	8 3	11.9	7 6	24.8	24.4	12.0	3 2	7 4	10 6	12.5
Fallbrook fine sandy loam											
577510	0 to 10	1 9	2.9	4.8	28 7	33 3	15 5	5.9	7 1	13 0	15 2
577511	10 to 24	3 1	5.1	4.0	24.0	32.4	15 7	5.7	10.1	15 8	16 3
Las Posas stony fine sandy loam											
577507	0 to 4	2 1	3 0	1 4	6.5	47 8	28.3	6 0	4.9	10.9	18.0
577508	4 to 16	1.0	1.5	1.8	6 7	46 4	28.8	8 2	6 0	14.2	17 7
577509	16 to 26	2.0	2.3	1 4	6.2	45.2	27 6	8 7	6.8	15 5	17.8
Konokti stony loam											
577533	0 to 10	4.3	5 0	6 3	10.1	19 8	35 2	12.6	7 5	20.1	22.4
577534	10 to 28	4.7	4.9	9 4	16 1	4 3	30 4	16 0	14.3	30.3	21 5
Escondido silt loam											
577501	0 to 10	2 0	2.4	2.4	4.9	29 6	50 0	3 3	4.9	8.2	16 5
577502	10 to 28	1 3	3 0	1 4	4 2	28.3	52.9	4.3	4.4	8.8	16.6
Altamont clay loam:											
577593	0 to 5	.6	.9	1.9	6 8	31 8	36 7	10.4	11.6	22.0	21.9
577594	5 to 20	.4	.5	1 0	5.7	21.0	30 3	19 5	21 9	41.4	28.1
577595	20 to 35	.4	9	7	5.0	26 5	35 4	14.3	17.4	31.7	29.0
Altamont clay:											
577551	0 to 10	.3	1 6	1 7	9 5	11.9	28 8	17 4	29 1	46 5	32.4
577552	10 to 24	.4	1 3	1 8	8.5	11 8	29 0	18 4	27 9	46.3	33.1
Ayar clay loam:											
577531	0 to 12	.2	.8	1.7	6.4	34.2	36.7	11 3	9 4	20 7	29.7
577532	12 to 36	.4	1.2	.7	5.0	35 3	35.3	11 4	11.5	22 9	29.9
Linne clay											
577529	0 to 10	1.6	6.0	8.9	17.3	13.9	21.5	10 3	21.2	31 5	29.4
577530	10 to 20	.9	7.0	10.4	12.8	12 2	19 3	13.8	24.2	38.0	20.2
Carlsbad loamy fine sand:											
577548	0 to 12	.6	13.7	21.7	36.6	16.5	5.9	3 0	1.9	4.9	5.2
577549	12 to 30	.6	17.7	24.9	28.8	11 3	6.3	3 3	6.5	8.8	6.7
577550	30 to 50	4.2	23.6	34.6	19.1	6.5	3 1	3 2	5.9	9 1	8.5
Olivenhain loamy fine sand											
577554	0 to 9	.4	3.0	8.0	51.1	22.0	8.3	3.0	3.7	6 7	8.7
577555	9 to 27	.3	.5	4.8	33.5	12.7	8 3	1.3	39.3	40.6	30.3
577556	27 to 36	.1	2.0	10.3	45.7	10.8	7.6	1.9	22.3	24.2	25.4
Las Flores loamy fine sand											
577535	0 to 7	1 5	13 3	16 1	34.6	17 7	8 1	1 9	6.7	8.6	9 1
577536	7 to 16	2.3	13 4	14.5	22.0	8.5	7 6	2.1	29.7	31.8	31.9
577537	16 to 36	1 3	11 6	36 1	19.7	8.6	12 5	1.3	9.6	10.9	19.7
Foster fine sandy loam:											
577566	0 to 12	.5	1 9	6.0	35 9	34.2	13 9	3 4	4 1	7 5	18.2
577567	12 to 72	.5	3 9	6 1	42 6	32 1	9 2	2.2	3 8	6.0	12.0
Elkhorn loamy sand:											
577561	0 to 15	.7	19 8	24.1	30.4	13 3	5 8	2 3	3.7	6 0	6 3
577562	15 to 50	1.0	10.9	35 2	27 6	9 8	3 9	1 7	9.8	11.5	8.2
577563	50 to 72	1 2	24.1	21 9	26.5	10 1	3.5	.1	11.9	12 0	9.3
Botella sandy clay loam:											
577570	0 to 14	9.1	13.0	11.5	13.7	16 5	12.8	5 8	17.7	23.5	20 8
577571	14 to 40	13.3	19.1	12.9	13.4	12.3	8.6	4.0	16 4	20.4	17.8

[1] Clay includes materials from 0.005 to 0.002 millimeter in diameter.
[2] Colloid includes materials less than 0 002 millimeter in diameter.

TABLE 3.—*Mechanical analyses of several soils from the Oceanside area, Calif.*—Continued

Soil type and sample No.	Depth	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay[1]	Colloid[2]	Total clay	Moisture equivalent
San Marcos fine sandy loam	*Inches*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
577520	0 to 14	6 3	7 4	8 2	23 0	31 6	14 6	4 5	4 9	9 4	16 0
577521	14 to 72	5 7	6 0	7 7	26.9	25 6	14.5	5 1	8 2	13 3	18 9
Salinas clay loam											
577596	0 to 12	4.9	6 3	3 8	29 1	20 8	11 8	5 9	17.5	23 4	20 4
577597	12 to 40	4 1	4.9	6 8	35.0	18.1	10 4	4 3	16 6	20 9	18.6
577598	40 to 72	3 6	5 8	4 0	13 4	22 4	20 0	13 4	17 6	31 0	25 4
Ramona sandy loam											
577588	0 to 5	3 4	5 9	8 9	31.9	29 2	12.7	3.5	4 8	8.3	10 8
577589	5 to 14	1 4	4 9	8 4	22.2	31 4	18.3	5 9	7.4	13 3	14 1
577590	14 to 30	2 3	6 1	4 2	20 4	29 4	15 6	5 9	16 4	22.3	18.0
577591	30 to 50	2.2	4.7	6 6	16 7	27 8	19 9	6.8	15 9	22 7	20 0
577592	50 to 72	3 1	7 3	4 3	21 5	31.1	15 2	4 6	14 3	18 9	19 6
Merriam fine sandy loam											
577503	0 to 12	2.2	4 6	5.6	14 5	32.2	27 3	5 6	7 1	13 3	17.0
577504	12 to 36	.8	3 3	2 8	9 3	24.3	21 6	14 6	23 1	37.7	26.9
577505	36 to 45	2 5	4 3	5 2	15 3	28.1	17.5	7.6	19 5	27.1	22 5
577506	45 to 65	5 4	8 6	3 6	13 6	28 6	19.2	5 1	16 2	21 3	23 4
Huerhuero fine sandy loam											
577573	0 to 12	6	1 1	1 0	43 8	33 4	9 4	3 0	7 5	10 5	11 6
577574	12 to 32	7	9	6	32 5	30 7	9 4	4 1	21 2	25 3	23 6
577575	32 to 52	4	5	1 0	49.7	26 5	8 2	1 9	11 7	13 6	15 4
Redding gravelly sandy loam:											
577538	0 to 7	6 0	15 7	9 2	20.4	21 3	18 4	4 0	4 8	8 8	12 2
577539	7 to 18	8 9	7 6	12 6	13 6	13 9	13 4	4 2	31 2	35 4	22 4

[1] Clay includes materials from 0.005 to 0.002 millimeter in diameter
[2] Colloid includes materials less than 0 002 millimeter in diameter.

SUMMARY

The Oceanside area is in the northwestern part of San Diego County, Calif., and comprises 577 square miles.

It consists of a mountainous region, covering the eastern half, and a coastal plain of broad flat-topped sea terraces on the west. Streams have cut deep valleys through the coastal-plain region to the sea. A number of valleys occur in the mountainous region, among them being Escondido, San Marcos, Green, and Poway Valleys.

A large part of the mountainous region is made up of rough stony land and rough broken land, which are nonagricultural. The Fallbrook and Vista soils are the most important agricultural soils of the mountainous region in the eastern part of the area. With irrigation, citrus fruits are grown in frost-free locations. The Las Posas, Konokti, and Escondido soils also occur in this region.

The Altamont, Diablo, Ayar, Linne, Tierra, Las Flores, and Olivenhain soils occur on the coastal plain. They are all underlain at a depth of less than 6 feet by consolidated or moderately consolidated material and are severely eroded in spots.

The Carlsbad and Elkhorn soils are developed on sandy beach deposits along the coast. A large part of the avocado, winter vegetable, bulb, and flower development of recent years has taken place on the Elkhorn soils, extending from Oceanside to Solana Beach.

The Hanford, Tujunga, Foster, Alviso, and Laguna are recent stream-laid soils. The Hanford, Foster, and Laguna are important agriculturally for alfalfa, truck crops, and beans.

The Greenfield, Botella, San Marcos, Ramona, and Salinas soils have slightly weathered profiles, indicated by a slight accumulation of clay or lime in the subsoil. All are good soils but not extensive.

The Merriam and Huerhuero soils have a heavy accumulation of clay in the subsoil, in addition to an accumulation of lime. Agriculture is somewhat restricted on these soils on account of the heavy subsoil.

The Redding and Monserate soils are characterized by hardpan layers. Miscellaneous soil materials include rough stony land, rough broken land, tidal marsh, river wash, and coastal beach and dune sand. These are nonagricultural soils.

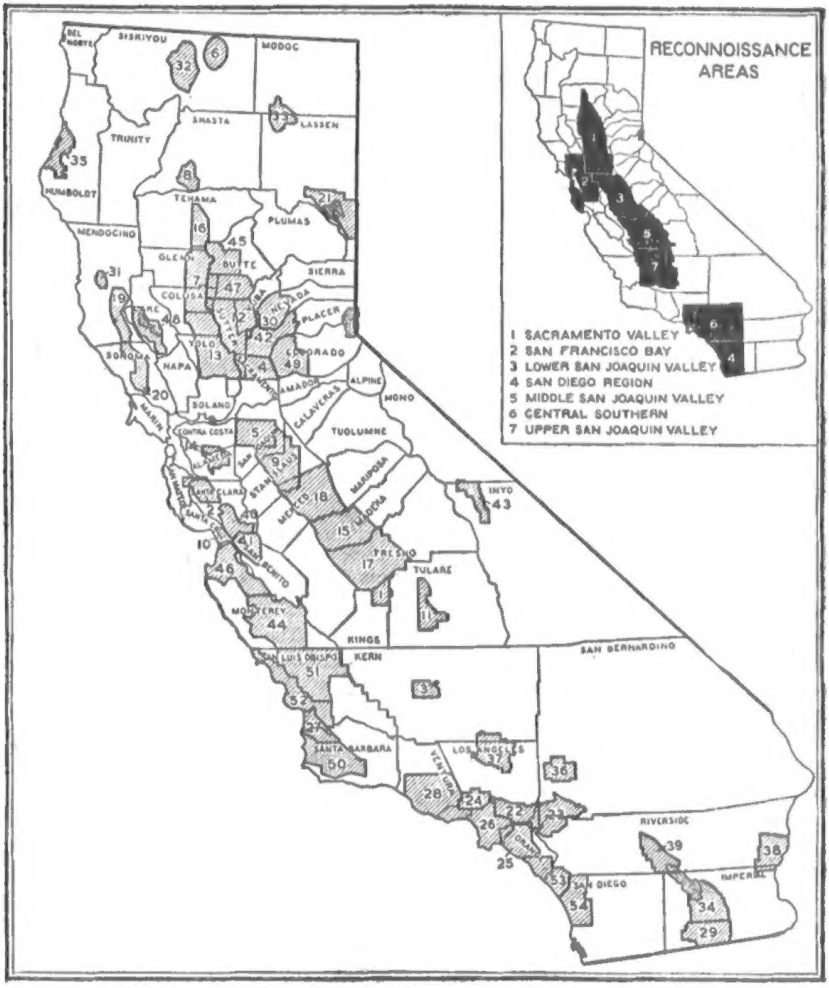
The agriculture of the area is largely governed by the climate and the water supply. Avocados and citrus fruits require frost-free locations. As the rainfall ranges from only 9 to 17 inches, most crops require irrigation. The water supply is limited at the present time, and water is expensive on the coastal-plain soils.

The temperatures along the coast are equable, there being an absence of either extremely hot or very cold weather.

○

Authority for printing soil survey reports in this form is carried in Public Act No. 269, Seventy-second Congress, second session, making appropriations for the Department of Agriculture as follows:

There shall be printed as soon as the manuscript can be prepared with the necessary maps and illustrations to accompany it a report on each soil area surveyed by the Bureau of Chemistry and Soils, Department of Agriculture, in the form of advance sheets bound in paper covers, of which not more than 250 copies shall be for the use of each Senator from the State and not more than 1,000 copies for the use of each Representative for the congressional district or districts in which a survey is made, the actual number to be determined on inquiry by the Secretary of Agriculture made to the aforesaid Senators and Representatives, and as many copies for the use of the Department of Agriculture as in the judgment of the Secretary of Agriculture are deemed necessary.



Areas surveyed in California, shown by shading

1. Hanford.
2. San Jose.
3. Bakersfield.
4. Sacramento.
5. Stockton.
6. Butte Valley.
7. Colusa.
8. Redding.
9. Modesto-Turlock.
10. Pajaro Valley.
11. Portersville.
12. Marysville.
13. Woodland.
14. Livermore.
15. Madera.
16. Red Bluff.
17. Fresno.
18. Merced.
19. Ukiah.
20. Healdsburg.
21. Honey Lake.
22. Pasadena.
23. Riverside.
24. San Fernando.
25. Anaheim.
26. Los Angeles.
27. Santa Maria.
28. Ventura.
29. El Centro.
30. Grass Valley.
31. Willits.
32. Shasta Valley.
33. Big Valley.
34. Brawley.
35. Eureka.
36. Victorville.
37. Lancaster.
38. Palo Verde.
39. Coachella Valley.
40. Gilroy.
41. Hollister.
42. Auburn.
43. Bishop.
44. King City.
45. Chico.
46. Salinas.
47. Oroville.
48. Clear Lake.
49. Placerville.
50. Santa Ynez.
51. Paso Robles.
52. San Luis Obispo.
53. Capistrano.
54. Oceanside.

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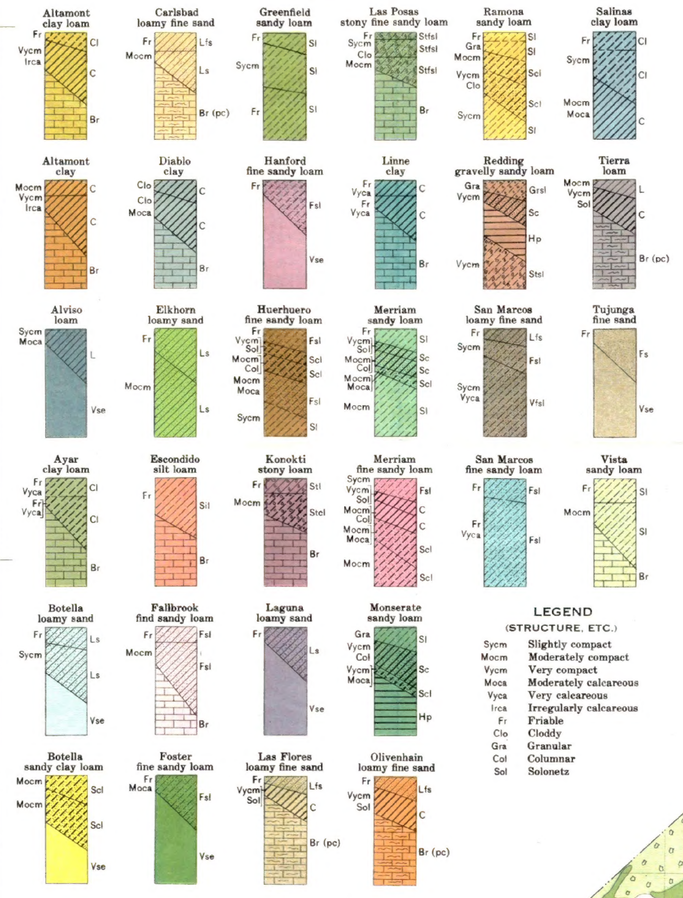
CURTIS F. MARBUT, IN CHARGE SOIL SURVEY

SOIL MAP
OCEANSIDE AREA
CALIFORNIA

UNIVERSITY OF CALIFORNIA
AGRICULTURAL EXPERIMENT STATION
E. D. MERRILL, DIRECTOR
CHARLES F. SHAW, IN CHARGE SOIL SURVEY

TYPICAL PROFILE DIAGRAMS
(6 feet deep)



LEGEND
(STRUCTURE, ETC.)

Sycm	Slightly compact
Mocm	Moderately compact
Vycm	Very compact
Moca	Moderately calcareous
Vyca	Very calcareous
Irca	Irregularly calcareous
Fr	Friable
Clo	Cloddy
Gra	Granular
Col	Columnar
Sol	Solonetz

LEGEND
(TEXTURE)

Ls	Loamy sand
Fs	Fine sand
Lfs	Loamy fine sand
Stsl	Stony sandy loam
Grsl	Gravelly sandy loam
Sl	Sandy loam
Stfsl	Stony fine sandy loam
Fsl	Fine sandy loam
Vfsl	Very fine sandy loam
Stl	Stony loam
L	Loam
Sil	Silt loam
Stcl	Stony clay loam
Scl	Sandy clay loam
Cl	Clay loam
Sc	Sandy clay
C	Clay
Hp	Hardpan
Vse	Variably textured stratified sediments
Br	Bedrock
Br (pc)	Bedrock, partially consolidated

LEGEND

Altamont clay loam — A
Gravelly phase — As
Alviso loam — Al
Ayar clay loam — Ay
Botella loamy sand — Bl
Brown phase — Bls
Botella sandy clay loam — Bs
Brown phase — Bss
Carlsbad loamy fine sand — Cl
Gravelly phase — Cls
Diablo clay — Dc
Elkhorn loamy sand — El
Escondido silt loam — Es
Fallbrook fine sandy loam — Ff
Foster fine sandy loam — Fl
Greenfield sandy loam — Gs
Calcareous-subsoil phase — Gss
Hanford fine sandy loam — Hf
Huerhuero fine sandy loam — Hs
Rough broken land — Rb
Rough stony land — Rs
Konokti stony loam — Ks
Laguna loamy sand — Ll
Altamont clay — Ac
Eroded phase — Ae
Linne clay — Lc
Merriam sandy loam — Ms
Brown phase — Mss
Merriam fine sandy loam — Mf
Clay phase — Mfc
Monserate sandy loam — Ml
Olivenhain loamy fine sand — Ol
Gravelly phase — Ols
Ramona sandy loam — Rl
Stony phase — Rls
Salinas clay loam — Sc
San Marcos loamy fine sand — Sl
Tierra loam — Tl
Tujunga fine sand — Tf
Vista sandy loam — Vs
River wash — Rv
Tidal marsh — T
Coastal beach and Dune sand — Co

CONVENTIONAL SIGNS

CULTURE
(Printed in black)

City or Village, Roads, Buildings, Wharves, Jetties, Breakwater, Levee, Lighthouse, Fort
Secondary roads and Trails
Railroads Steam and Electric
Bridges, Ferry
R.R.crossings, Tunnel
Ford, Dam
School or Church Cemeteries
Mine or Quarry Mine dumps Made land
Bluff, Escarpment, Rock outcrop and Triangulation station
Stony and Gravelly areas
Soil boundaries
Boundary lines
Boundary lines
Boundary lines
U.S.township and section lines

RELIEF
(Printed in brown or black)

Contours Depression contours
Prominent Hills Mountain Peaks
Sand, Wash, and Sand dunes
Shore and Low water line, Sandbar

DRAINAGE
(Printed in blue)

Streams
Lakes, Ponds, Intermittent lakes
Intermittent streams
Springs, Canals and Ditches, Flumes
Swamp Salt marshes
Submerged marsh Tidal flats

The above signs are in current use on the soil maps. Variations from this usage appear in some maps of earlier dates.

Macy H. Lapham, Inspector, District 5.
Soils surveyed by R. Earl Storie, University of California, in charge, and E. J. Carpenter, U. S. Department of Agriculture

BASE MAP IN PART FROM
U. S. GEOLOGICAL SURVEY SHEETS

Scale 62500
1 0 1 2 3 4 Miles
1 0 1 2 3 4 5 Kilometers
Contour interval 25 feet.
Datum is mean sea level.

Field Operations
Bureau of Chemistry and Soils
1929